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POTENTIAL OFF-STREAM RESERVOIR SITES IN THE BIG HOLE RIVER BASIN

January, 1979

Water Resources Division
Montana Department of Natural Resources and Conservation
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SUMMARY

This report summarizes past and current interest in water development in the Big Hole River basin as well as water resources and use. It also includes discussions concerning the basin's dewatering problems and how some of the benefits of a reservoir might be difficult to realize because of the problems involving water rights and water distribution. Chapter five, entitled "Site Identification and Evaluation," summarizes the methods used in the study and describes twenty-two sites that looked promising on first inspection. Chapter six, entitled "Recommendations," provides seven potentially feasible reservoir sites, suggests specific areas requiring further study at each of the seven sites and throughout the Big Hole River basin, and lists possible sources of funding.

From an initial list of 120 reservoir sites off the main stem of the Big Hole River, DNRC selected seven sites to recommend for further study. Each of these seven sites is located on a tributary of the Big Hole River; hence, they are not "off-stream" reservoirs as that term is normally used. Off-stream reservoirs are those placed on intermittent streams and filled primarily with water from another source. While six off-stream sites were originally identified, none of them satisfied DNRC's criteria for a suitable reservoir site.

The seven sites recommended include a site on Canyon Creek, a site on Johnson Creek, the old Pattengail Creek site, a Francis Creek site, a French Creek site, and the Fat Man and Thin Man sites on Trail Creek. The two Trail Creek sites, the Francis Creek site, and the site on Johnson Creek would be able to provide supplemental flows to only the upper portion of the river. Further studies should be completed to determine whether there is sufficient reason to construct a reservoir at any of these sites.

The demand for water in the basin has not yet been sufficiently determined. Studies should be completed to determine whether there is a demand for water, how much and where water needs to be provided, and how much water users would be willing to pay for water. If a reservoir is finally constructed, an adequate means for ensuring the delivery of water should be implemented in the basin.

This report was prepared by the Department of Natural Resources and Conservation for the Forty-sixth Legislature as directed by House Joint Resolution 80.

ACKNOWLEDGMENTS

The Department of Natural Resources and Conservation would like to acknowledge Gary Fritz, who provided guidance; Chris Tootell, who did the research and initially wrote the report; Pam Tennis Smith, who did historical research; Bill Long, especially, who prepared the discusson of the economics of irrigated agriculture; June Virag and Gordon Taylor, who prepared the graphics; Don Howard, who prepared the cover; Gary Wolf, who did the layout; Patti McCarthy, who did the typesetting; Janet Cawlfield, Lynda Howell, and Barbara Williams,who typed the report; and Mark Nicholson, who edited it.

I. INTRODUCTION

HOUSE JOINT RESOLUTION 80

During the 1977 Montana legislative session, the Forty-fifth Legislature passed House Joint Resolution 80 (HJR 80) instructing the Department of Natural Resources and Conservation (DNRC) to study the feasibility of off-stream storage on the upper Big Hole River. The reasons stated in HJR 80 for the investigation of the feasibility of an off-stream reservoir included providing water for irrigated agriculture, preservation of the Big Hole and Jefferson rivers as fishing streams, and providing safety from uncontrolled flood waters. The results of the investigation subsequently conducted by DNRC are contained in this report to the Forty-sixth Legislature as mandated by HJR 80 and include:

1. A description of each site considered;
2. The benefits and costs associated with each unit;
3. A recommendation indicating the most pratical units to investigate further; and
4. Potential sources of funding for the construction of a unit.

The agricultural lands in the Big Hole River basin and in areas immediately downstream have soil and climatic conditions that make irrigation an attractive means of increasing and stabilizing agricultural productivity. Substantial acreages in this area are currently under irrigation and there is a possibility that additional acres in this area would be irrigated if water were available.

The Big Hole River below Divide has been designated a blue ribbon trout stream. In dry years, however, the dewatering effects of diversion of river water have deteriorated the quality of this fishery. It is possible that this deterioration could be reversed by augmenting late-season flows.

Flooding from spring runoff and unseasonably heavy rains has damaged private property and public facilities in the Big Hole and Jefferson river basins. A storage reservoir could control some of these destructive flows although a reservoir on a tributary stream would have only a limited capacity to do this.

PAST INTEREST IN WATER DEVELOPMENT

HJR 80 does not represent the first time interest in water development has been expressed in the Big Hole River basin. Several statutes have aided irrigation and water storage development in the Big Hole River basin. The incentives provided in these statutes, for example, aided the establishment of the Beaverhead Water Company in 1915 which still operates in the Big Hole (OSS 1975). In 1919, the Butte Water Company began construction of a water line from Smith Fork Reservoir, and this line still conveys water across the Great Divide to Butte.

A 1921 project plan investigated the possibility of irrigating 47,000 acres in the Crow Creek area near Toston. The major storage facility was to be located on the Big Hole River near Glen. The Rivers and Harbors Act of June 28, 1938, was the statutory impetus that began investigations by the Bureau of

Reclamation for irrigation, power and flood control in the Missouri River basin. Out of this study, a comprehensive development plan called Senate Document 191 was compiled (USDI 1958). These reconnaissance-type investigations were expanded into more detailed studies by the 1944 and 1946 Flood Control acts (USDI 1958). These investigations also identified the dam site near Glen as an excellent location for a major water storage and power generation facility. This recommendation eventually led to two detailed project studies and plans in 1958 and 1967 for the construction of Reichle Dam (USDI 1958, USDI 1967).

Although many reservoir sites have been studied in the Big Hole River basin, the Reichle project has been the largest. The Reichle proposal which included an extensive canal system and an intermediate storage reservoir has not been built because of unsatisfactory economic return projections and major adverse environmental impacts. Interest in Reichle Dam still exists, and during the Forty-fifth Legislature, a resolution was proposed to update the Reichle study (HJR 1) but was not passed. Within the same legislative session, the legislature adopted HJR 80 initiating the investigation reported here.

THE BIG HOLE

In HJR 80, the Forty-fifth Legislature specifically instructed the DNRC to study "off-stream storage on the upper Big Hole River". DNRC interpreted this to mean storage sites that are not on the main stem of the river. The physical, political and demographic features of the area are shown in figure 1.

The Big Hole of southwestern Montana, often referred to as the upper Big Hole River basin, is flanked on the west and north by the high, rugged Bitterroot and Anaconda ranges. The majority of the Big Hole River's major tributaries originate in the areas of these ranges that receive up to 150 cm (60 in) of precipitation annually. The Pioneer Mountains, less rugged than the Bitterroot Range, form the eastern side of the Big Hole and contain the Wise River, the Big Hole River's largest tributary. The high rolling hills at the southern end of the Big Hole divide the Big Hole River basin from the basin of the Beaverhead River which eventually joins the Big Hole River near Twin Bridges to form the Jefferson River.

The extensive forest lands in the basin of the Big Hole River are predominated by lodgepole pine, which has commercial value as lumber, house logs, posts and poles. The Douglas fir in the area also has commercial value. The subalpine and alpine areas have forests of spruce and fir rendered noncommercial by the trees' stunted growth caused by the severe climate, and the areas' inaccessability. Figure 2 shows the study area's forest resources.

As the extent of forest lands in the area suggests, much of the area is administered by the U.S. Forest Service. Also much land is administered by the Bureau of Land Management (BLM). Various state lands are intermingled with federally and privately owned land. Consideration of the feasibility of any water development must include the ownership of the site and the lands that would be inundated. Figure 3 shows the ownership of land in the study area.

FIGURE 1.
THE BIG HOLE RIVER BASIN

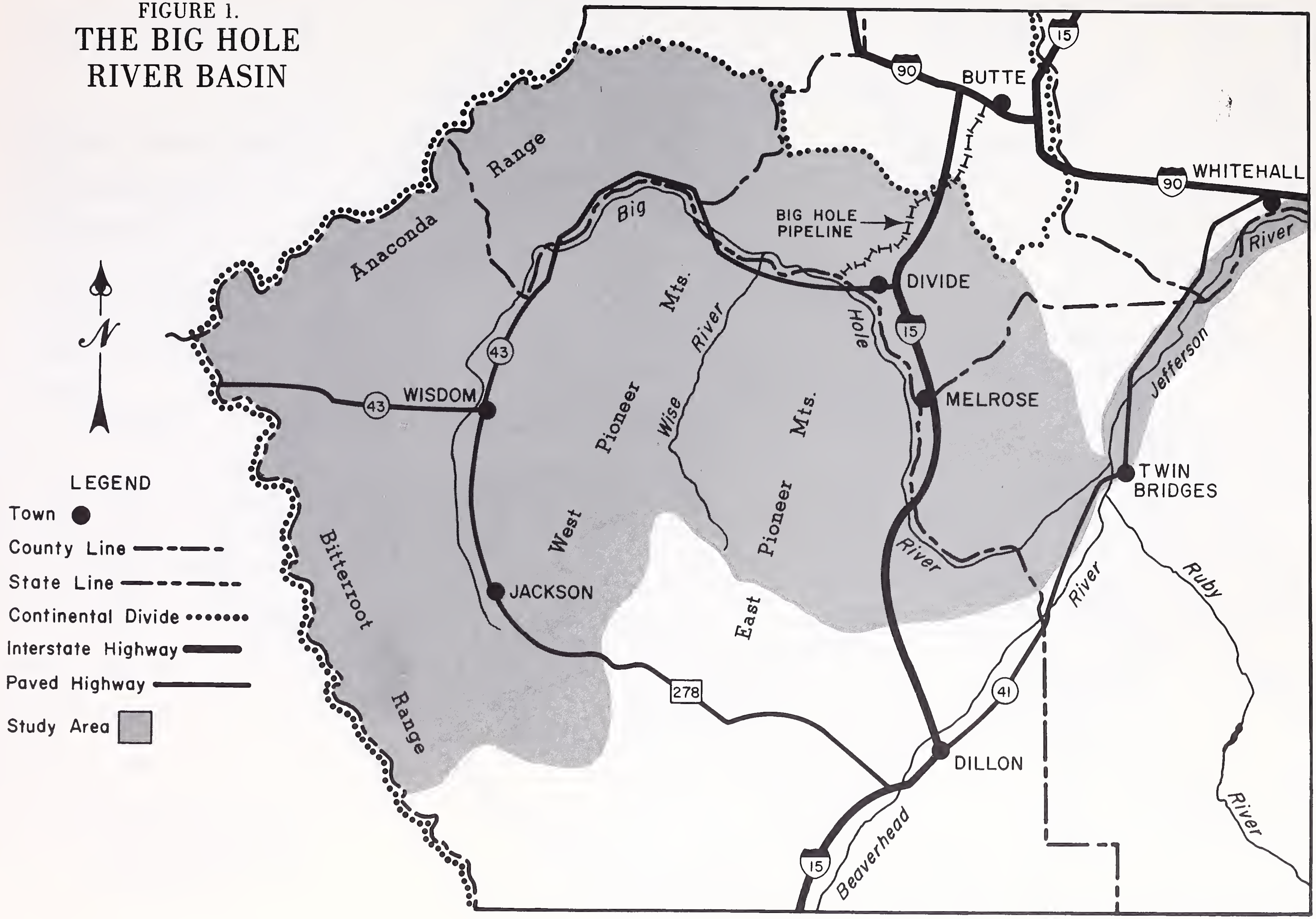
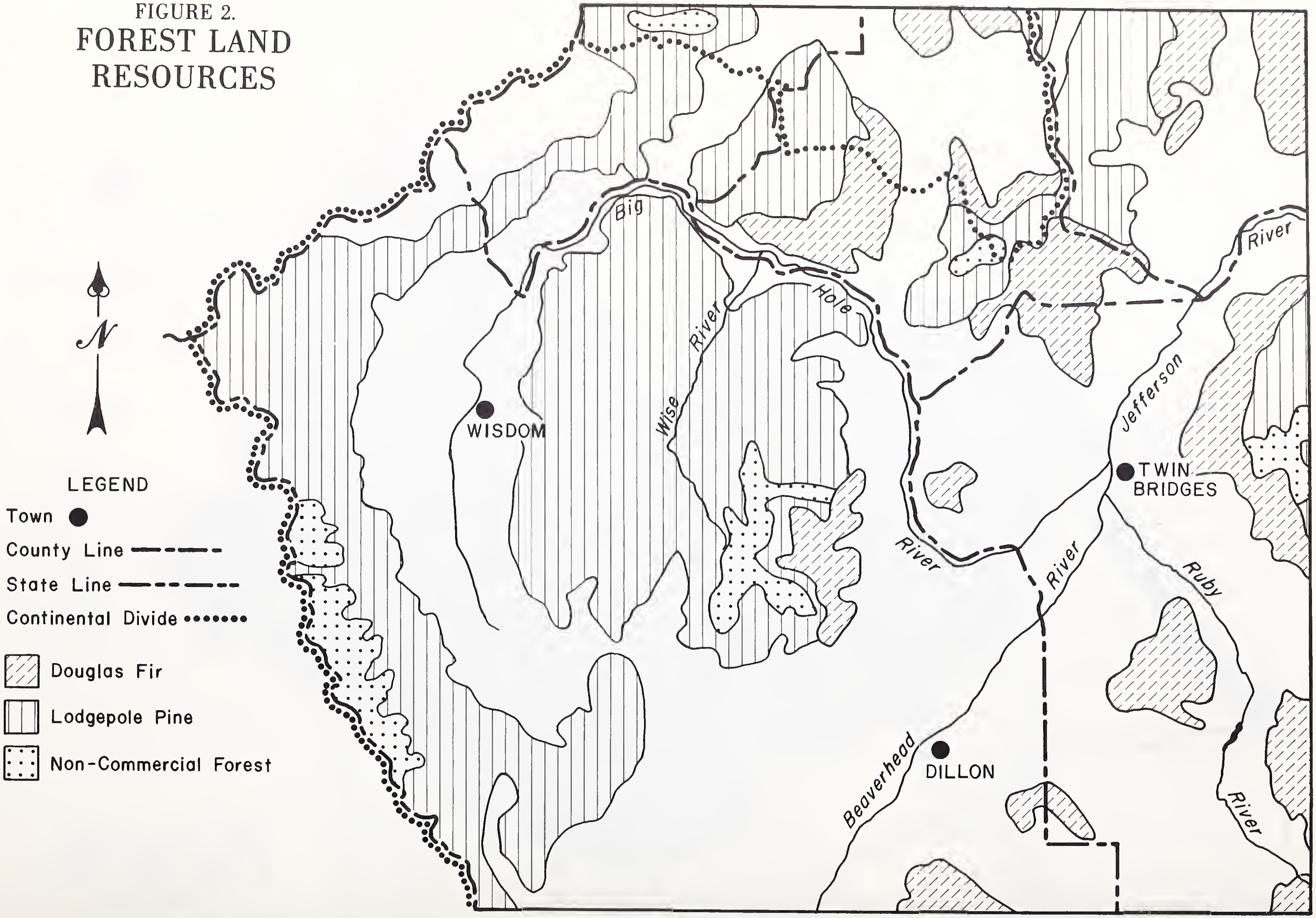
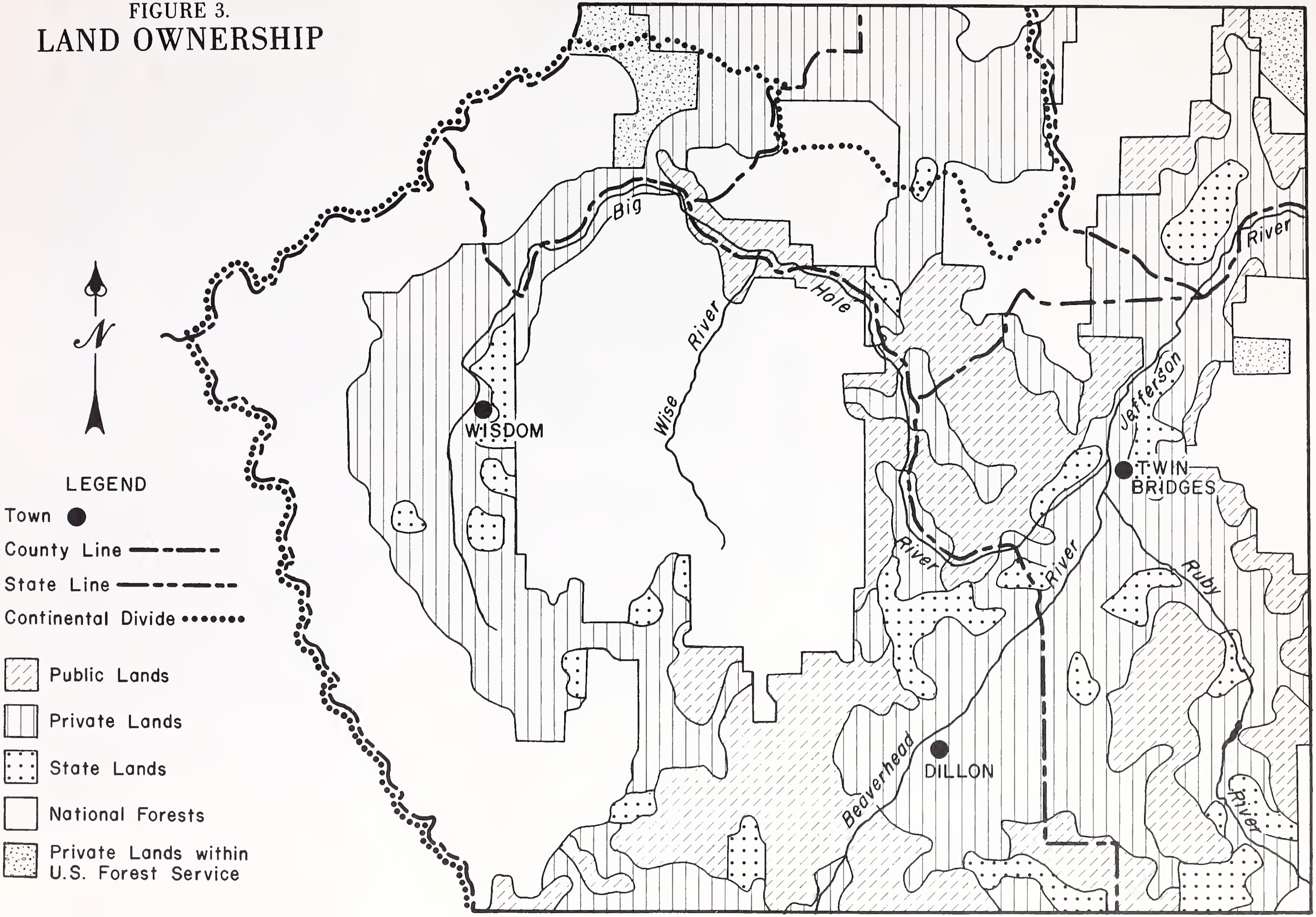


FIGURE 2.
FOREST LAND RESOURCES



SOURCE: USDA, U.S. Forest Service

FIGURE 3.
LAND OWNERSHIP



SOURCE: Bureau of Land Management

II. WATER RESOURCES

The average annual precipitation of the Big Hole River basin ranges from less than 25 cm (10 in) to more than 150 cm (60 in) of moisture, providing an abundance of water. The water produced in the mountains, especially in those areas of the Bitterroot Range that receive large amounts of precipitation, flows in well defined streams until it approaches the valley floor. On the valley floor, however, some of the water of many of these streams disappears as it infiltrates into the ground or is diverted. Swampy areas are abundant, and many areas benefit from natural subirrigation.

GROUND WATER

Between the valley floor and bedrock lie three permeable and semi-permeable layers which account for the upper Big Hole's abundant ground water. The top layer, essentially rock waste deposited by streams, consists of gravel, sand, silt, and volcanic ash. This permeable layer is separated from another permeable layer of coarse gravels by a semi-permeable layer of alluvium resulting from the period when the valley was covered by a lake. The depth of these layers may exceed 150 m (500 ft).

The result of the watershed production and water-carrying gravels underlain by impervious rock is that most of the upper Big Hole has a high water table. Since 1973, the wells drilled in the upper Big Hole have had an average depth of 30 m (97 ft) and an average pumping level of 12 m (41 ft). Areas lower in the basin and along the Jefferson and Missouri rivers already depend on ground water for irrigation. Depletion of these ground-water sources in the future may cause a greater demand for water development in the Big Hole River basin.

SURFACE WATER

Stream-gaging records for the station near Melrose show that the Big Hole River's average annual flow at that point amounts to 818,641 acre-feet, while the maximum annual flow has been 1,364,470 acre-feet and the minimum, 322,720 acre-feet. A hydrograph of the river's flows is presented in figure 4. Appendix A provides additional gaging data from stream-gaging stations in the basin.

Normally, the Big Hole River provides adequate water for all relying on it, including the basin's irrigators. Occasionally, however, diversions have dewatered the river to the point of creating water shortages and significantly lowering the river's high quality of water. During the summer of 1966, a portion of the river near Twin Bridges became dry, damaging the aquatic ecosystem of large segments of the river. The dry year of 1977 also reduced the river's flow to a low level, although unusually heavy late-season rains provided water for late summer irrigation and saved the aquatic habitat from severe damage. The low flows in 1977 brought attention to the dewatering problems of the river, especially those related to water quality.

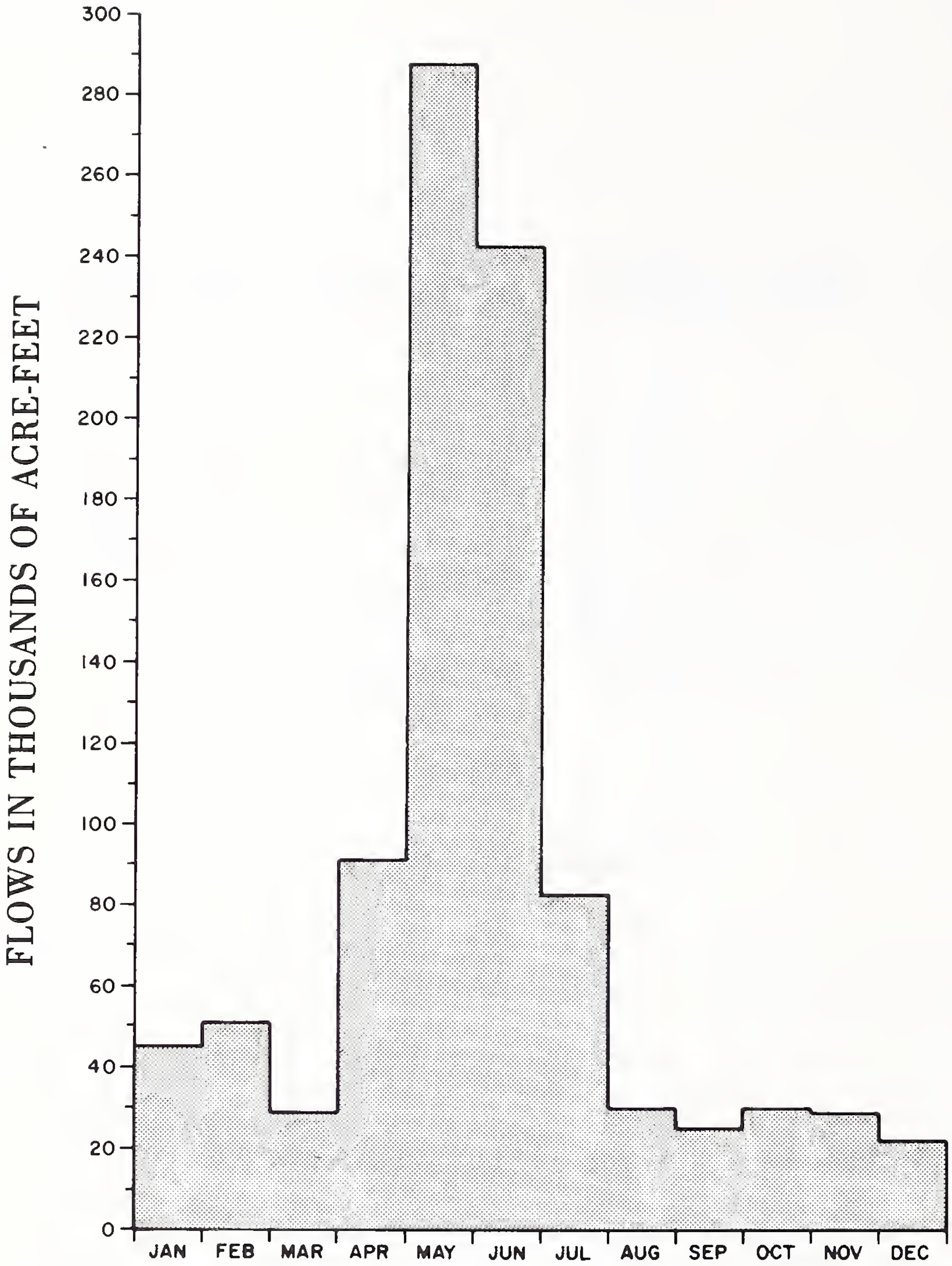


FIGURE 4. AVERAGE MONTHLY FLOWS OF THE BIG HOLE RIVER NEAR MELROSE. (Period of record: 1924-1977)

WATER QUALITY

Generally, the Big Hole River has water of an excellent quality. It is a moderately hard calcium bicarbonate-type water with low turbidity and low sulfate, chloride, sodium, and toxic metal concentrations. Stream temperatures considered adverse for the growth and propagation of salmonids and associated aquatic species, however, have been recorded at the USGS gaging station near Melrose. These temperature fluctuations appear to be cyclic and may be affected by irrigation return flows. Channelization and construction of diversion works have increased stream sediment loads and turbidity (DHES 1975).

Algae growth in the Big Hole River during the summer months is limited by the lack of nitrogen. The addition of more inorganic nitrogen from irrigation return flows coupled with increased stream temperatures would encourage algae growth. The increased algae growth and reduced stream flow would create critically low dissolved oxygen levels.

It may be possible to maintain the Big Hole River's good water quality and augment low irrigation-season flows by providing water from a sizeable off-stream reservoir.

EXISTING RESERVOIRS

The eleven small reservoirs in use in the basin provide about five thousand acre-feet of irrigation water. Of these reservoirs, nine are located in the East Pioneer Mountains and drain eastward toward the lower Big Hole River. Mussigbrod Lake in the Anaconda Range and Schultz Reservoir in the Bitterroot Range drain toward the upper Big Hole River. These reservoirs are listed in table 1.

TABLE 1.

EXISTING RESERVOIRS IN THE BIG HOLE RIVER BASIN.

Name	Capacity in acre-feet
Agnes Lake	1,420
Anchor Lake	450
Bond Lake	90
Boot Lake	952
Deerhead Lake	207
May Lake	52
Mussigbrod Lake	1,100
Pear Lake	500
Schultz Reservoir	110
Tub Lake	297
Waukena Lake	200
TOTAL	**5,378**

III. WATER USE

IRRIGATED AGRICULTURE

Most of the water presently diverted from the Big Hole River goes to irrigated agriculture. Table 2 shows the water requirements for current levels of irrigation in the area. The shorter growing season and better water supply partly accounts for smaller demand for additional irrigation water in the upper Big Hole. The growing season in the upper Big Hole averages sixty-eight days. In the Twin Bridges area, it averages 126 days. In addition, the high water table of some areas in the upper Big Hole makes irrigation unnecessary. Because there may be little demand for irrigation water in the upper Big Hole, water from a water storage project may be difficult to market in that area. Water may be more marketable in the Twin Bridges area where the demand for irrigation water seems to be greater than the supply.

The trend in the number of irrigated acres harvested has varied from county to county in the area. Broadwater and Jefferson counties have experienced slight increases, while Beaverhead, Deer

TABLE 2.

CURRENT IRRIGATION REQUIREMENTS ALONG THE BIG HOLE, JEFFERSON AND MISSOURI RIVERS ABOVE CANYON FERRY DAM.

County	Irrigated acres	Crop	Irrigation requirement* (inches)	Irrigation water used (acre-feet)
Beaverhead				
upper Big Hole Valley	106,669	native grass	15.33	136,270
lower Big Hole Valley	11,001	alfalfa	26.47	24,266
Broadwater				
Missouri River Valley	56,393	alfalfa	26.57	124,863
Deer Lodge				
upper Big Hole Valley	8,530	native grass	15.33	10,897
Jefferson				
Jefferson River Valley	15,164	alfalfa	28.1	35,509
Madison**	41,322	alfalfa	26.47	91,149
Silver Bow				
upper Big Hole Valley	576	native grass	15.33	736
lower Big Hole Valley	4,064	alfalfa	26.47	8,965
TOTAL	**243,719**			**432,656**

*Reflects irrigation efficiency

**Includes lands along Big Hole and Jefferson rivers.

Lodge, Silver Bow, and Madison counties have all experienced decreases since the early 1950s. Since the mid-seventies, however, there has been an increase in irrigated acres which accounts for the increased demand for water. Because this is a short period, this may not reflect the demand at the time a storage reservoir would begin to supply water.

The number of irrigable acres in the study area far exceeds the number of acres actually irrigated. Lands in the upper Missouri River basin have been systematically appraised according to soil, topography and climate, and placed into four classes of irrigation potential based on ability to produce crops under sustained irrigation farming. Class 1 contains irrigable lands with the highest productive potential while class 3 includes the lands having the lowest. Class 3C contains lands where the climate severely limits production potential. The results of this classification, shown in tables 3 and 4, indicate a potential for a large increase in the number of acres irrigated.

Figure 5, a map delineating agricultural land use, shows the predominance of the range cattle industry in the area. Large areas of range land, many of which lie on benches adjacent to the flood plain of the Big Hole River, are irrigable and could be developed if water could be delivered economically.

TABLE 3.

THE IRRIGATION POTENTIAL OF AGRICULTURAL LANDS IN COUNTIES THAT MAY BE AFFECTED BY WATER STORAGE IN THE BIG HOLE RIVER BASIN.

County	Class 1	Class 2	Class 3	Class 3C	Total irrigable	Irrigated	Total of irrigated and irrigable
Beaverhead*		395	72,319	3,300	76,014	117,670	193,684
Broadwater	461	21,378	108,782		130,721	56,393	187,014
Deer Lodge*		380	5,460		5,840	8,530	14,190
Jefferson***		4,937	30,655		35,592	15,164	50,756
Madison**	5	16,448	53,355		69,808	41,322	111,130
Silver Bow*			3,330		3,330	4,640	7,970
TOTAL	**466**	**43,538**	**273,901**	**3,300**	**321,205**	**243,539**	**564,644**

*Includes lands in the Big Hole River basin only.

**Includes lands along the Big Hole and Jefferson rivers only.

***Includes lands along the Jefferson River only.

TABLE 4.

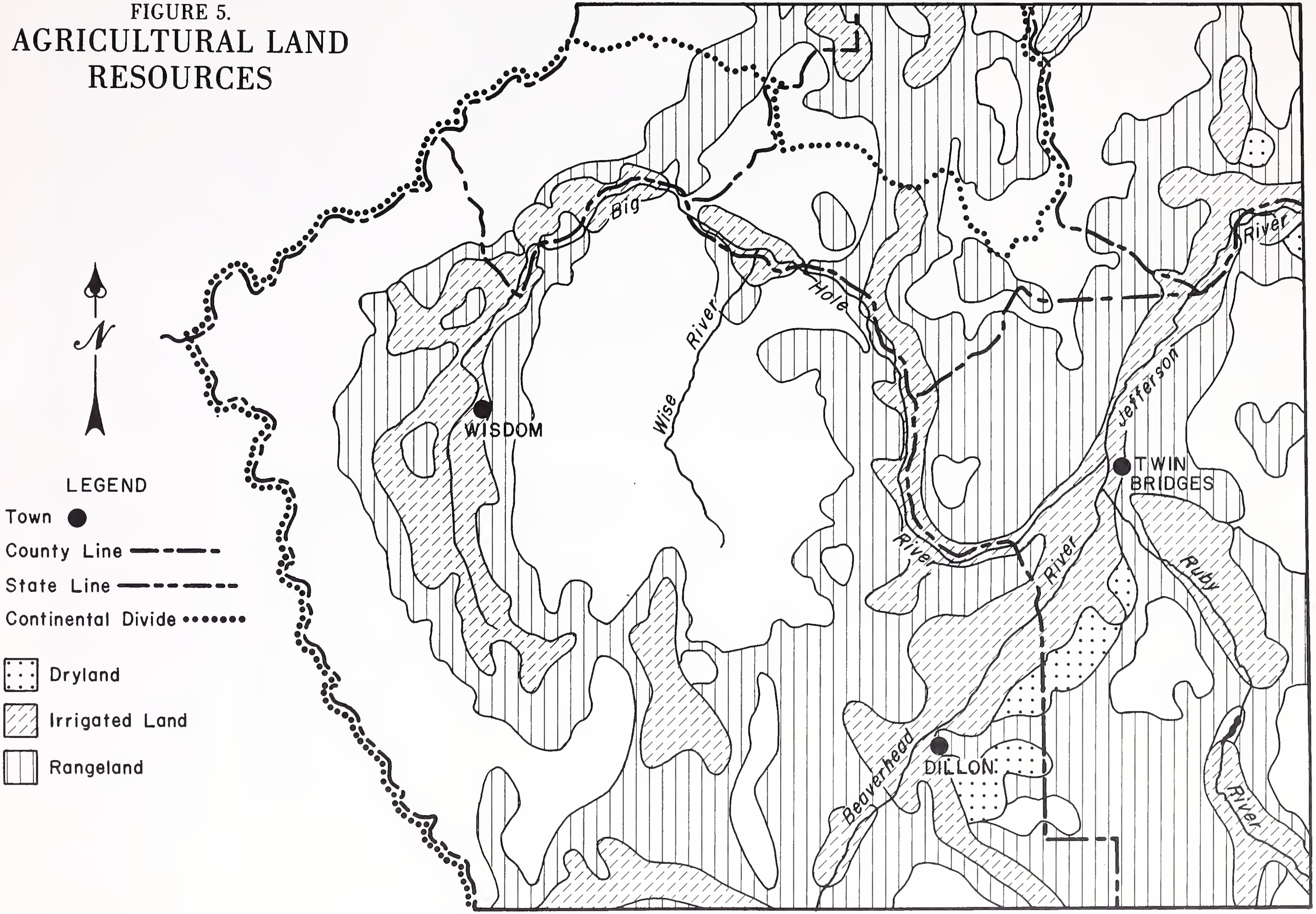
THE IRRIGATION POTENTIAL OF AGRICULTURAL LANDS IN RIVER BASINS THAT MAY BE AFFECTED BY WATER STORAGE IN THE BIG HOLE RIVER BASIN.

River	Class 1	Class 2	Class 3	Class 3C	Total irrigable	Irrigated	Total of irrigated and irrigable
Big Hole		3,992	89,153	3,300	96,445	139,773	236,024
Jefferson*	105	19,388	80,995		100,488	48,218	148,706
Missouri**	361	20,158	103,482		124,001	56,173	180,174
TOTAL	**466**	**43,538**	**273,630**	**3,300**	**320,934**	**244,164**	**564,904**

*Includes lands along the river in Madison, Jefferson, and Broadwater counties.

**Includes all irrigated and irrigable lands in Broadwater County except those lands adjacent to the Jefferson River.

FIGURE 5.
AGRICULTURAL LAND RESOURCES



SOURCE: Committee for Rural Development

MUNICIPAL AND OTHER USES

A significant amount of water diverted from the Big Hole River supplies the Butte municipal water system. On an average, the Butte Water Company pumps forty acre-feet of the Big Hole River over the continental divide each day. The water requirements of all other communities in the basin are minor and are supplied by wells.

Besides irrigation and municipal uses, water is appropriated in the Big Hole River basin for other uses, although they use a minor amount of water. Some water is used in the mining operations in the basin. The predominantly rural population appropriates domestic water from wells. Also, recreational facilities such as Forest Service campgrounds require some water. These uses, however, demand very little of the basin's surface water.

FISHERIES AND WILDLIFE

The Big Hole River and its tributaries provide an excellent fishery resource. Although cutthroat trout, grayling and mountain whitefish are native to the basin and have previously dominated the fishery, these fish have been largely displaced by exotic brown, brook and rainbow trout.

Mountain whitefish and grayling, though now accompanied by brook trout, still dominate the upper reach of the river above Wise River. The population of grayling which inhabits the river above Wise River represents the last major river-dwelling population of this fish in the United States outside Alaska.

Brown and rainbow trout and mountain whitefish are the dominant game fish in the lower reach of the river. The section of the river between Wisdom and the mouth is nationally renowned for quality angling and has been designated as a blue ribbon trout stream. This reach receives a great deal of fishing pressure from both residents and nonresidents and the money brought into the area by these fishermen is important to the area's economy. This reach of the river, however, suffers from dewatering during the late summer and, in some years, portions of the river are completely dewatered. The effects of such dewatering are catastrophic to aquatic life, although the productivity of the fishery can recover after periods of plentiful flows.

Brook trout dominate most of the numerous tributaries of the Big Hole River but native cutthroat trout, grayling, and burbot are also found. The lower reaches of many of these tributary streams also suffer from severe dewatering during the late summer, and this may be responsible for the hastened demise of cutthroat trout and grayling.

Although the Big Hole River naturally has low flows in late summer, diversions for agriculture further reduce the amount of water in the river. These dewatering effects result in a loss of aquatic habitat and subsequently a loss of the aquatic invertebrates that are the bulk of the diet of game fish. Consequently, game fish may lack the food necessary for growth and survival. More damaging, however, is the elevated temperature that accompanies the low flows. During the periods of low flows in late summer, a large proportion of the river is made up of irrigation return flows which are warmer than the natural flow. Past observation of the river near Twin Bridges has shown that the river's stream temperature has exceeded levels considered lethal to trout and other salmonids (DFG 1974).

Although it is possible that these dewatering problems on the Big Hole River's main stem could be alleviated by allowing releases from a reservoir to augment low flows, construction of a reservoir could have adverse effects on the local fishery and the wildlife at the reservoir site.

Moose, elk, mule deer, antelopes, mountain goats, black bears, numerous small game species, birds and perhaps wolves inhabit the Big Hole River basin. A reservoir on Francis Creek would reduce the habitat of the only antelope herd in the basin. A French Creek reservoir would block a portion of the seasonal migration route of elk. Several potential reservoir sites are important moose winter range. Most likely, the native fishery at and above any reservoir site would suffer adverse effects. The wildlife at and surrounding a reservoir site may also be affected adversely. This would be the price of providing additional irrigation water and in-stream flows for the main stem.

IV. WATER RIGHTS AND RELATED PROBLEMS

RECENT APPROPRIATIONS

Since 1973, when the Water Use Act came into effect, DNRC has issued ten water use permits for the appropriation of surface water in the Big Hole River basin. The diversions pursuant to these permits appropriate more than three thousand acre-feet of water annually, mostly for irrigation. Most of these permits carry conditions that allow diversion only during the spring runoff season when water is plentiful. DNRC has also issued thirty-two certificates for the appropriation of ground water, largely for domestic use and use as stock water.

The construction agency or organization would have to obtain a water use permit or a water reservation before it could construct a water project. Also since all of the projects recommended for further study would appropriate flows in excess of fifteen cubic feet per second and annual amounts in excess of ten thousand acre-feet, clear and convincing evidence would have to be provided that prior appropriators would not be adversely affected (89-885(6) R.C.M. 1947).

Water from such a project would, of course, be sold to various users in the basin and would be delivered via the river as allowed by 89-891.1 R.C.M. 1947. Ranchers may want to purchase the water for irrigation, the City of Butte may want to purchase water if delivery is feasible and DFG may want to purchase water for in-stream flows. The Montana Power Company may favor construction of a reservoir in the upper Missouri basin. The company claims that irrigation diversion interfers with their water rights for their hydroelectric projects on the Missouri River. The company would hope that a reservoir would provide additional water to irrigators who might otherwise deplete low late-summer flows claimed by the company. Also, if a project were large enough, the company may be interested in purchasing water for use at its hydroelectric facilities.

THE PROBLEMS OF DELIVERING WATER

Delivering the water once it is purchased may be more difficult than merely releasing water from the reservoir. Because diversions on the Big Hole River are not monitored, it is very possible that water purchased from the reservoir owner would be diverted before it reached its intended destination, especially if that destination were a substantial distance downstream from the reservoir. Such problems are not uncommon in Montana. A project would have the potential of creating a situation where although the natural flow of the river might be nearly depleted, it would carry large amounts of stored water released from the reservoir. Believing that the water in the river is its natural flow and that they are entitled to it, water right and water use permit holders might wrongly divert the water.

Also, because the reservoir would create stable flows in the river, potential water users may believe that the Big Hole River has sufficient water for new appropriations. Rather than buy water out of the new reservoir, potential water users would apply to DNRC for water use permits. Since the Big Hole River lacks sufficient stream gaging, it would be difficult to demonstrate that the river has no water for further appropriations. Although it is possible to modify the permits so that they do not interfere with reservoir releases and senior appropriations (89-886 R.C.M. 1947), it would be difficult to control water piracy through facilities authorized by such permits. Enforcement of such limitations would require legal action costly in both time and money. Problems similar to this are currently happening in the Milk River basin.

Until these problems are solved, prospective water purchasers may hesitate to buy water from a project. The reservoir owner could control the diversion of stored water among the water purchasers by petitioning the court to appoint a water commissioner to monitor each of their head gates. Permittees' head gates as well as stored water could also be regulated by the water commissioner according to 89-1001 R.C.M. 1947. The cost of such regulations would be shared by the purchasers and permittees. Such a water commissioner, however, may not be able to solve the problem of misappropriation of water since he would not have the authority to control the head gates of water right holders who claim a non-decreed or non-permitted water right.

If water use increases, the need for a water monitoring system would become even more necessary. Implementation of such a system would serve to prevent water disputes that would otherwise be inevitable.

V. SITE IDENTIFICATION AND EVALUATION

IDENTIFICATION OF POTENTIAL RESERVOIR SITES

The search for suitable reservoir sites began with the compilation of a comprehensive list of reservoir sites with capacities greater than five thousand acre-feet in the Big Hole River basin. Some sites had capacities smaller than five thousand acre-feet because they were identified on maps where it was impossible to tell how large they were until they were planimetered. Because HJR 80 requested DNRC to study the feasibility of off-stream storage in the upper Big Hole River basin, none of the 120 sites included on the list are located on the main stem of the Big Hole River. Screening criteria were developed to identify those sites that would satisfy the intent of HJR 80. They are discussed below.

DNRC eliminated all sites located on tributaries that joined the main stem above the point where Highway 43 crosses the river near Wisdom. A reservoir located on a tributary joining the Big Hole River above this point would probably not be able to provide supplemental flows to the lower reach of the river. Even a reservoir on a tributary that joined the main stem in the upper valley above the Big Hole River Canyon may not be able to provide supplemental flows to the lower reach of the river but could provide supplemental flows to dewatered portions of the upper river. All reservoir sites that would have a firm annual yield of less than five thousand acre-feet or had a physical capacity less than five thousand acre-feet were also eliminated. Although a reservoir having such a firm annual yield or capacity might still not be able to provide the supplemental flows intended by HJR 80, a reservoir having a smaller firm annual yield or capacity would not. All potential reservoir sites that could not be constructed, operated, maintained and repaired for about twenty dollars per acre-foot of water produced by the reservoir, or less, were also eliminated. The figure of twenty dollars was selected because the benefits produced by a reservoir could not be expected to exceed that amount. Irrigators have the ability to pay between three and four dollars per acre-foot while the balance of the benefits would be comprised of unquantifiable values such as flood control, fishery, recreation, aesthetics, in-stream flow, etc. (see appendix C).

Only twenty-two sites met all of the preliminary criteria. Table 5 provides basic information about each site and how many of the criteria were satisfied by each site. The remaining twenty-two sites, which are mapped in figure 6, were more closely examined to identify each site's advantages and disadvantages. Only seven sites passed this second evaluation. A detailed description of each site including reasons for its elimination or recommendation is included in this chapter.

TABLE 5.
PRELIMINARY EVALUATION OF ALL RESERVOIR SITES.

Name of project	Land description	Location[1]	Storage capacity[2]	Firm yield[3]	Cost[4]	On-site evaluation[5]	Total capacity (acre-feet)[6]	Dam height (feet)[7]	Surface area (acres)
Alder Creek	1N 12W Center Sec 24	X[8]	X	X					
Big Hole River, NF	2S 17W Sec 24	X	X	X[9]					
Big Hole River	7S 15W NW¼ Sec 8	[10]							
Big Lake Creek	5S 16W NE¼ Sec 6	[10]							
Big Lake Creek	5S 17W SE¼ Sec 7	[10]							
Big Lake Creek	5S 17W Sec 10	[10]							
Birch Creek	5S 10W SE¼ Sec 23	X	X	X	X		6,204	148	115
Bryant Creek	1N 13W Sec 35	X	X						
Bull Creek	6S 14W NW¼ Sec 1	[10]							
Butler Creek	2S 17W NW¼ Sec 32	X	X						
Butler Creek	2S 17W SW¼ Sec 34	X	X						
Butler Creek	3S 17W N½ Sec 3	X	X						
California Creek	3N 11W Sec 29	X							
Camp Creek	2S 8W SE¼ Sec 17	X	X						
Camp Creek	2S 8W NW¼ Sec 20	X	X						
Camp Creek	2S 8W W½ Sec 20	X							
Canyon Creek	2S 9W Center Sec 6	X	X	X					
Canyon Creek	2S 10W Sec 9	X	X	X					
Canyon Creek	2S 9W SW¼ Sec 6	X	X	X					
Canyon Creek	2S 10W E½ Sec 12	X	X	X	X	X	6,391	189	105
Canyon Creek	2S 11W Sec 24	X	X	X					
Canyon Creek	2S 11W Sec 24	X	X	X					
Clam Creek	1N 15W SW¼ Sec 30	X							
Deep Creek	2N 12W Sec 29	X	X	X	X		17,956	113	506
Divide Creek	2N 9W Sec 30	X							
Divide Creek, NF	2N 10W Sec 24	X	X						
Doolittle Creek	1S 14W Sec 20	X	X						
Doolittle Creek	1S 14W Sec 29	X							
Englebaugh Creek	7S 15W SW¼ Sec 9	[10]							
Fishtrap, WF	2N 14W NW¼ Sec 26	X							
Francis Creek	2S 15W Sec 15	X	X	X[11]	X	X	9,667	73	880
French Creek	2N 12W Sec 16	X	X	X	X	X	6,405	94	210
Howell Creek	1N 15W Sec 21	X							
Jacobson Creek	3S 12W Sec 34	X	X	X	X		21,281	112	350
Jerry Creek	2N 10W Sec 33	X	X						
Jerry Creek	1N 10W Sec 6	X	X						
Jerry Creek	1N 10W Sec 7	X							
Jerry Creek	1N 10W Sec 30	X	X	X					
Jimmie New Creek	1N 11W S½ Sec 26	X	X	X[11]					
Johnson Creek	1S 16W N½ Sec 30	X	X	X	X	X	11,274	73	455
Johnson Creek	1S 17W SW¼ Sec 24	X	X	X					
La Marche Creek	2N 13W SW¼ Sec 5	X	X	X	X		14,324	116	257
La Marche Creek	2N 13W Sec 16	X	X	X	X		15,382	99	277
Lambrecht Creek	2S 12W SW¼ Sec 19	X	X						
Lost Horse Creek	2S 13W N½ Sec 3	X	X						
May Creek	2S 18W SW¼ Sec 20	X	X						
May Creek	2S 18W W¼ Sec 22	X	X						
McVey Creek	2S 15W NW¼ Sec 2	X	X						
Miner Creek	6S 16W SE¼ Sec 3	[10]							
Moose Creek	1S 9W SE¼ Sec 33	X	X						
Moose Creek	4S 17W Sec 16	X							
Mudd Creek	1N 14W Sec 4	X	X	X					
Mussigbrod Creek	1N 16W SW¼ Sec 29	X	X	X					
Old Tim Creek	4S 13W Sec 29	[10]							
Old Tim Creek	4S 13W Sec 33	[10]							
Pattengail Creek	2S 12W SW¼ Sec 10	X	X	X	X	X	9,040	50[12]	400
Pattengail Creek	2S 12W W½ Sec 18	X	X	X					
Peterson Creek	7S 14W NW¼ Sec 27								
Pintlar Creek	1N 15W Sec 3	X	X	X	X		7,928	51[12]	330
Pintlar Creek	1N 15W Sec 14	X							
Pintlar Creek	1N 15W Sec 23	X							
Pintlar Creek	1N 15W Sec 26	X							
Placer Creek	2S 17W SE¼ Sec 16	X	X						
Plimpton Creek	1S 15W SE¼ Sec 17	X							

Name of project	Land description	Location[1]	Storage capacity[2]	Firm yield[3]	Cost[4]	On-site evaluation[5]	Total capacity (acre-feet)[6]	Dam height (feet)[7]	Surface area (acres)
Quartz Hill Gulch	1N 10W Sec 5	X	X						
Rock Creek	3S 10W Sec 34	X	X	X					
Ruby Creek	3S 17W S½ Sec 30	X	X	X					
Ruby Creek	3S 17W S½ Sec 30	X	X	X					
Ruby Creek	3S 17W S½ Sec 30	X							
Ruby Creek	3S 18W S½ Sec 13	X	X						
Sawlog Creek	1N 13W W½ Sec 17	X	X						
Sawlog Creek	1N 13W S½ Sec 17	X	X						
Sawlog Creek	1N 13W Sec 21	X							
Seymour Creek	2N 12W W½ Sec 19	X	X	X					
Seymour Creek	2N 12W W½ Sec 30	X	X	X	X		7,137	97	180
Seymour Creek	2N 13W E½ Sec 2	X							
Seymour Creek	2N 13W SE¼ Sec 2	X							
Squaw Creek	1N 14W Sec 35	X	X						
Steel Creek	3S 14W Sec 4	X							
Steel Creek	3S 15W SE¼ Sec 3	X	X	X[11]	X		13,425	80	523
Stevenson Creek	2S 18W E½ Sec 27	X	X						
Stewart Creek	1N 13W Sec 7	X							
Thompson Creek	1N 15W NW¼ Sec 30	X	X						
Tie Creek	1S 18W SW¼ Sec 14	X	X	X					
Toomey Creek	1N 14W Sec 25	X							
Trail Creek	2S 17W SE¼ Sec 18	X	X	X	X		19,790	128	500
Trail Creek	2S 17W N½ Sec 21	X	X	X	X		21,720	145	460
Trail Creek	2S 17W Sec 22	X							
Trail Creek	2S 18W SW¼ Sec 4	X	X	X					
Trail Creek	2S 18W N½ Sec 5	X	X	X	X		5,018	105	180
Trail Creek	2S 18W SE¼ Sec 9	X	X	X					
Trail Creek	2S 18W SE¼ Sec 14	X	X	X	X	X	14,320	96	490
Trail Creek	2S 18W Sec 15	X	X	X	X	X	11,926	83	480
Trapper Creek	2S 9W Sec 30	X							
Trapper Creek	2S 9W N½ Sec 33	X							
Trapper Creek	2S 9W NE¼ Sec 34	X	X	X					
Vipond Creek	2S 11W Sec 12	X	X						
Warm Spring Creek	4S 14W N½ Sec 2	[10]							
Warm Spring Creek	4S 14W S½ Sec 2	[10]							
Warm Spring Creek	5S 14W Sec 20	[10]							
Willow Creek	4S 10W SE¼ Sec 20	X							
Willow Creek	4S 10W NW¼ Sec 34	X	X	X					
Willow Creek	4S 10W NE¼ Sec 35	X	X	X					
Willow Creek	4S 10W NW¼ Sec 36	X							
Willow Creek	4S 10W NW¼ Sec 36	X	X	X					
Wise River	1S 12W Sec 25	X	X	X					
Wise River	2S 12W NE¼ Sec 15	X	X	X					
Wise River	2S 12W SW¼ Sec 27	X	X	X	X		55,120	125	1,130
Wise River	3S 12W Sec 4	X	X	X					
Wise River	3S 12W Sec 20	X	X	X	X		13,259	97	359
Wyman Creek	3S 12W W½ Sec 19	X	X	X					
Wyman Creek	3S 13W Sec 25	X	X	X	X		8,787	71	400
Wyman Creek	3S 13W Sec 34	X	X	X	X		6,377	62	220
A Dry Gulch	1N 13W NE¼ Sec 19	X							
A Dry Gulch	2S 15W E½ Sec 15	X	X	X[11]					
A Dry Gulch	2S 16W S½ Sec 10	X	X	X[11]					
A Dry Gulch	3S 9W SE¼ Sec 15	X	X	X[11]					
A Dry Gulch	4S 8W NW¼ Sec 36	X							
A Dry Gulch	5S 8W SW¼ Sec 3	X	X	X[11]					

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[1] Sites located on tributaries that join the Big Hole River below the bridge on Highway 43 west of Wisdom.

[2] Sites having a storage capacity greater than five thousand acre-feet.

[3] Sites having a firm annual yield greater than five thousand acre-feet.

[4] Sites having a development and operating cost of about twenty dollars or less.

[5] Sites considered worthy of further consideration following a multi-discipline on-site investigation.

[6] Total capacity maximum practical capacity based on topographic features at the site and natural stream flow (completed for only sites that satisfied the first three criteria).

[7] Dam height includes twenty feet of freeboard which is the vertical distance between the water level at normal capacity and the spillway.

[8] Each "X" indicates that the site satisfied the criterion.

[9] Was not considered further because the site was located on a national monument.

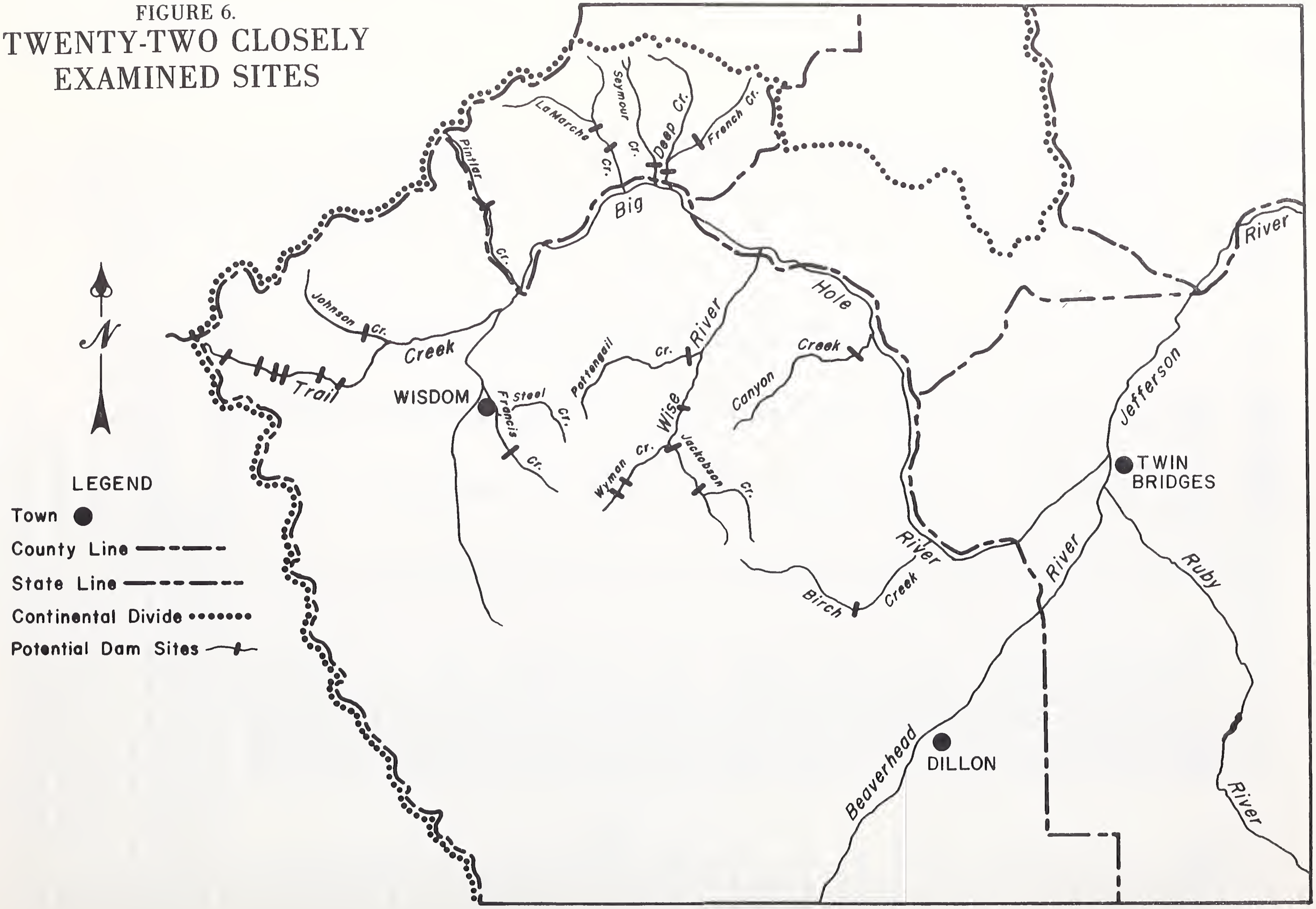
[10] Sites that did not meet the first criterion.

[11] Does not have sufficient natural flows, but has possibility of diversion into reservoir.

[12] Fifteen feet of freeboard.

FIGURE 6.

TWENTY-TWO CLOSELY EXAMINED SITES



SITE EVALUATIONS

1. Birch Creek; SE¼, Section 23, T5S, R10W, MPM

The Birch Creek reservoir site, previously known as the Apex Dam site, is located entirely within the Beaverhead National Forest at the lower end of the Big Hole River basin and very close to Dillon. An impoundment constructed at this site and supplemented with 5,160 acre-feet of water from the Willow Creek basin via an existing canal which is owned and operated by the West Bench Irrigation District would create a reservoir containing 6,200 acre-feet and having a surface area of 115 acres. The reservoir could be enlarged but the cost per acre-foot would be higher. The Bureau of Reclamation studied this site extensively during the 1950s.

Because of the weak, soft foundation of the Amsden formation, the site is not suitable for an earthen dam. A concrete dam would alleviate only some of the geological problems while greatly adding to the project's cost.

A dam at this site would destroy the stream ecosystem as well as about 190 acres of riparian vegetation and range. Because the dam would prevent most of the brook trout spawning migration, it would do great damage to the local fishery, even though for a short time fishing would be excellent in the reservoir. The value of the present fishery may be substantially limited by the large irrigation diversion to the West Bench area. The Forest Service management plan did not set a wildlife management objective in this area; however, some moose winter in the lower creek bottoms. Presumably this would include the creek bottom that a Birch Creek reservoir would inundate.

A Forest Service road presently providing access to a ranger station and the Birch Creek Bible Camp would have to be re-routed to replace a portion that would be inundated by the reservoir.

About 13,000 irrigable acres in the West Bench Irrigation District immediately below the site could be partially serviced from a Birch Creek reservoir. Water continuing in the creek channel would be available to the Glen, Twin Bridges, Silver Star, and Whitehall vicinity. The West Bench Irrigation District, however, owns and operates both the Willow Creek diversion and all of that water. Consequently little of the diverted water would be available for sale from the project.

Although this site would control only a minor portion of the Big Hole River basin, it would offer some flood control benefits to the residents living along Birch Creek below the dam. The site is also strategically located to aid the most severely dewatered portion of the Big Hole River. Entering the river 36.3 km (22.5 mi) above the mouth, Birch Creek water could provide supplemental water for nearly half of the dewatered blue ribbon portion of the Big Hole River. Five thousand acre-feet of irrigation water released from Apex Dam in July and August destined for Silver Star would create a sustained flow of nearly forty cubic feet per second or nearly one quarter of the low flows of the 1977 summer.

Recreation access to the lake would be excellent since the Forest Service road coming from the site enters Interstate 15 approximately 13 km (8 mi) to the east. The Beaverhead National Forest's Land Management Plan has designated the lands that would be inundated for dispersed recreational opportunities.

Because of extensive geologic problems, the costs associated with correcting them, and the already marginally high development costs, this project is not currently feasible. Should water become a severely limiting factor to agriculture on the lands between Twin Bridges and Whitehall, the value of the water may increase enough to justify a concentrated geologic study to reevaluate those problems.

2. Canyon Creek, Fourth Site; E½, Section 12, T2S, R10W, MPM

Water from a Canyon Creek reservoir would enter the Big Hole River near the top of the lower Big Hole River valley. This reservoir would have a capacity of 6,390 acre-feet supported from natural flows of Canyon Creek and its tributary Vipond Creek. When full, the lake will have a surface area of about 105 acres. The firm annual yield from this project would be 9,540 acre-feet of water.

The local geology is composed of Mission Canyon limestone. Several fractures are present, along with some caves near the top of the outcrops. The extent of the fractures and caves could only be determined by core drilling at the site. The alluvium of Canyon Creek is probably not more than 9 to 15 m (30-50 ft) thick. Suitable fill material may not be in the immediate vicinity.

A dam constructed at this site would produce a short term improvement in fishing. The Canyon Creek fishery—mostly brook trout with some rainbow trout—would be partially destroyed by the placement of a reservoir on this site. The lands that would be inundated are considered part of an extensive deer winter range. Some elk also use this area.

Most of the lands that would be inundated are parts of the Forest Service's rest rotation grazing allotments. Approximately 125 acres of the allotments would be inundated. The dam site is located just inside a Forest Service management unit that has some archeologic and historically valuable sites. There are several kilns in the Trapper Creek and Canyon Creek drainages. A limestone kiln used in the late 1800s is located at the dam site. The Forest Service's management plan for this area calls for an archeologic survey on these sites. Because of the poor condition of the existing roads, there would probably be no need to re-route any inundated segment of raod. A reservoir would offer very little flood control value to residents along the Big Hole River, except for one residence at the mouth of Canyon Creek.

A reservoir at this site could provide needed summer in-stream flow augmentations to 79 km (49 mi) of the 89 km (55 mi) of the blue ribbon trout fishery currently in jeopardy. There are no known diversions on the 4 km (2.5 mi) of Canyon Creek between the reservoir site and the Big Hole River so flows released would enter the river without significant loss. It would afford DFG an excellent source of water for an in-stream flow reservation.

Because the area that would be inundated has very little current recreation value, the development of a reservoir at this site would add new recreational opportunities. Currently there is little, if any, recreation at the site. The reasons are access, and more desireable recreational areas nearby. The most direct access is a minor road just 6 km (4 mi) from Interstate 15 to the site. However, a private chemical plant discourages travel on this road. The other access, from the adjacent Trapper Creek drainage, is via a maintained Forest Service access road, and eroded jeep trail.

While the canyon immediately below and the lands well upstream offer outstanding scenery, the lands adjacent to the reservoir pool are less spectacular and may be enhanced by a reservoir. Mud flats caused by seasonal fluctuations in the reservoir level may not be too extensive because of the steep terrain.

A reservoir at the Canyon Creek site would provide ranchers in the Melrose, Glen and Twin Bridges area excellent access to irrigation water. Because of the relatively large firm annual yield there could be considerable amounts of water for new and supplemental irrigation.

The economic cost of development would be $20.97 per acre-foot at 6 5/8 percent interest. Although this would make the site marginally feasible at best, the validity of this figure is questionable. The measurements that were done to arrive at the embankment requirement came from a 1:62,500, fifteen minute quadrangle sheet. This map has an eighty foot contour interval which is a very gross scale. An inspection at the site revealed that the dam would be at a neck. The embankment that this site would require should be investigated through a survey at the site.

The Canyon Creek site should be considered for further study of the uncertainties about this site in geology and cost estimates. An archeologic study should also be done on the site to determine the value of kiln at the dam site in relation to the others in the area and to search the site thoroughly. This site's potential value of water from this strategic location for irrigation and in-stream flows should be carefully considered.

3. Deep Creek; Section 29, T2N, R12W, MPM

A reservoir located on Deep Creek would have a annual yield of 19,300 acre-feet from a reservoir of 18,200 acre-feet. Water from this project would enter the Big Hole River at the upper end of the main canyon.

An investigation of the site conducted by the Bureau of Reclamation in 1941 indicated no geologic problems with the site.

The reservoir site is part of a important deer and elk migration route. It is also winter habitat for moose. Elimination of the free flowing status of Deep Creek and French Creek would greatly impede eastern brook trout migration and destroy the gravel beds needed for spawning. The reservoir would produce a short-term improvement in fishing, however.

The land that would be inundated is part of the Mount Hagen Ranch land acquisition which is managed by DFG and consequently DFG could possibly operate the reservoir to the advantage of in-stream flows. Since the state already owns this land, there would be no land acquisition costs. The terms of the grant that allowed the purchase of the Mount Hagen Ranch, however, require that any improvements made must have wildlife and recreation benefits that would be equal to or exceed the detrimental effects incurred by such improvements. It would be difficult to justify this project based on this requirement if it were considered by itself. The short-term fishing benefits and marginal recreation that would be created would be an inadequate mitigation for the destruction of five hundred acres of habitat under the terms of Mount Hagen Ranch acquisition agreements. It is not certain whether off-site benefits such as in-stream flow augmentation on the lower Big Hole River could be considered sufficient mitigation.

A small ski area's access road, chalet facilities, and parking lot would be inundated by this reservoir. The relocation of these facilities plus the reduced vertical rise of this already small hill may result in the abandonment of the ski area. Two or three miles of Highway 274 presently running through what would be the east abutment of the dam and continuing up the valley would be inundated and would have to be relocated.

This reservoir would regulate about one hundred square miles of highly productive watershed. The high peaks of this drainage basin produce over 150 cm (60 in) of precipitation annually.

Because the flows produced by this project could be expected to reach Twin Bridges during the irrigation season, the in-stream flow benefits would be extensive. The water would not enter the river in as strategic a location as the Canyon Creek site, but the large volume that could be released would be able to reach the lower river.

The recreation value of the reservoir after summer draw down would be greatly reduced by the presence of extensive mud flats. Only the area immediately above the dam would remain desireable to year-round recreation. The reservoir would provide some water-based recreation within an hour's drive from Butte and Anaconda.

The agricultureal benefits would be distributed from Wise River to Twin Bridges approximately 129 km (80 mi) downstream. Water from this project would enter the Big Hole River at the upper end of the main canyon. The water would have to travel considerable distances to get to most of the users, but this does not pose a problem with this size of storage since there are relatively few water users in the canyon that extends to Divide. This site is also upstream from the Butte municipal pumping plant and could provide water for Butte during future shortages.

The project would cost under 4 million dollars, with an annual operation, maintenance and repair cost of about twenty thousand dollars. This produces an amortized annual payment of $14.82 per acre-foot at 6 5/8 percent. The costs added by reimbursement or relocation of the skiing facilities that the reservoir would inundate would add to the cost. Road relocation alone would add about fifteen percent to the total project cost.

The greatest asset of this site is its size and yield. The relatively low development costs combined with a large annual yield make this site appear promising. The economic appeal, however, is lost to the costs incurred by the highway relocation of and the economic mitigation to the ski area owners. In addition to these factors, the extensive loss of habitat on lands specifically purchased and managed for fish, wildlife and recreation makes this site currently undesireable for further consideration.

4. Francis Creek; Section 15, T2S, R15W, MPM

The Francis Creek site is located three miles southeast of Wisdom, Montana. Its capacity would be 9,670 acre-feet with the same annual yield because a majority of the storage would be diverted from the Big Hole River. The lake created would have a surface area of 880 acres.

The geology of the site is poor. The site is flood plain alluvium setting on a tertiary lake bed. The lake bed deposits may be 150 m (500 ft) thick in some portions of the upper valley. It would seem unlikely that there is any bedrock close to the surface to give a dam a firm foundation. The reservoir could present a threat to the town of Wisdom, 3 to 5 km (2-3 mi) below the dam on the flood plain.

There is a small fishery in the stream with a small population of cutthroat and rainbow in the headwaters. The reservoir would temporarily improve the fishing and favor the rainbow. The brook trout fishery would probably be completely destroyed within a few years because of lack of suitable spawning water. The land that would be inundated are winter habitat for deer and elk. A small herd of antelopes are gradually increasing in the vicinity. This reservoir would substantially reduce the range of this species.

The land is privately owned and would require payment to the landowner and easement for recreation. The lands are presently used for grazing and perhaps some hay production. This, of course, would be lost.

This project would provide only minor flood control, but it would be a source of in-stream flows. The water would be available in the upper valley from Wisdom to the head of the canyon but the demand for water there appears to be relatively small. Because water released from this dam would be more than 190 km (120 mi) from the mouth of the Big Hole River, it is unreasonable to assume noticeable benefits would be realized in the Twin Bridges area.

A reservoir at this site would cost $8.68 an acre-foot. Although the reservoir would be relatively inexpensive the apparent lack of a safe footing for the project renders this site prohibitively unsafe. A soil and geologic investigation should be conducted to confirm this observation.

5. French Creek; Section 16, T2N, R12W, MPM

The French Creek site, located just 3 km (2 mi) upstream from the Deep Creek site on French Creek, the main tributary of Deep Creek, has the potential for a 210 acre reservoir that would have a capacity of 11,400 acre-feet yielding 9,000 acre-feet of water annually. This site is close to the Deep Creek site and subsequently has much in common with it.

This reservoir site is located on Mount Hagen Ranch acquisition, as is the Deep Creek site. The same problems of mitigating habitat loss exist here. The much smaller size of the reservoir would not be expected to disrupt the game migrations greatly.

A French Creek project would not require road relocation and would not affect the ski area.

This impoundment would control flows from the forty-two square miles of drainage basin above the site, and there could be a reasonable recreation pool at this site. The slope on three sides is fairly steep, hence, the mud flats would not be nearly as extensive as at the Deer Creek reservoir, although they could easily comprise one hundred acres.

The irrigation and in-stream flow benefits to the Big Hole River would be only a third of the Deep Creek site. Considering the diversions that cause the dewatering of the lower Big Hole River, Twin Bridges would be the farthest that substantial irrigation water could be expected to reach.

The cost for this project would be $14.84 per acre-foot of water at 6 5/8 percent interest.

Although this site has definite economic appeal, until DFG determines the effects this project would have on wildlife, this site should not be studied further. DFG should determine whether the benefits accrued to the lower Big Hole River would mitigate the adverse effects caused at the site.

6. Jacobson Creek; Section 34, T3S, R12W, MPM

The Jacobson Creek site, located in the most productive headwaters of the Wise River drainage, is 42 km (26 mi) above the mouth of the Wise River and over 145 km (90 mi) from the mouth of the Big Hole River. The reservoir would store 21,280 acre-feet, yield 16,820 acre-feet annually, and have a surface area covering approximately 350 acres. The addition of a 1.2 km (.75 mi) canal from Mono Creek would add four thousand acre-feet of water each year.

The reservoir would inundate Jacobson Meadows, currently a summer habitat for deer, moose and elk, and still in a pristine state. Part of the pack trail leading to Torrey Lake would be inundated and would have to be re-routed.

The major irrigation and in-stream benefits from this project would be upstream from where HJR 80 desired to have them. Releases could be allotted between in-stream flows and irrigation in the Wise River, which irrigation diversion often dewaters, and the lower Big Hole River. The irrigation return flows in the Wise River would contribute to more in-stream flows in the Big Hole River. A reservoir here might also improve water quality below the dam by settling heavy metal contaminants originating from abandoned mines in the Elkhorn area.

The recreation created by the reservoir would replace much of the stream fishing, hiking and backpacking occurring in Jacobson Meadows. A substantial recreation pool could be maintained since the valley that the reservoir would inundate is very flat and the valley walls are steep. Fishing for brook, rainbow and cutthroat trout would be improved temporarily. The water quality of the lake may prove to be poor from heavy metal loading.

Construction and operating costs would bring the annual cost of an acre-foot of water to $18.66 at 6 5/8 percent interest. The addition of the canal from Mono Creek would increase the cost of this project.

Because of the high development costs and the location of the reservoir in relation to both irrigation, in-stream flow values and aesthetic value of Jacobson Meadows, this site need not be investigated further.

7. Johnson Creek; W½ Section 30, T1S, R16W, MPM

A reservoir constructed on Johnson Creek in Section 30, T1S, R16W, MPM could be one of several different sizes. The general rule at this site, unfortunately, is that the larger the reservoir is, the higher the cost. The largest potential reservoir would have a capacity of 13,335 acre-feet, yield 15,905 acre-feet, and cost $12.75 per acre-foot for construction, operation, maintenance and repair. The smallest potential reservoir would have a capacity of 5,916 acre-feet, yield 9,698 acre-feet, and cost $11.22 per acre-foot. Several intermediate reservoir sizes are possible.

Little is known about the geology of this site. It should be investigated to determine geological suitability.

8. La Marche Creek; SW¼, Section 5, T2N, R13W, MPM

A reservoir on La Marche Creek in the SW¼ of section 5 of T2N, R13W would have a capacity of 14,324 acre-feet, a firm annual yield of 20,793 acre-feet, and a surface area of 257 acres.

This site is on the edge of the Anaconda-Pintlar Wilderness area where most of the reservoir would lie.

The reservoir would be about 145 km (90 mi) from the mouth of the Big Hole River. This distance would not prevent releases from the dam from reaching the lower valley since the releases would enter the Big Hole River in its canyon where there are few diversions.

The project would cost $18.92 per acre-foot. Because of this relatively high cost and the difficulties associated with encroachment on the wilderness area, this site should not be studied further.

9. La Marche Creek; Section 16, T2N, R13W, MPM

A reservoir located on La Marche Creek in section 16 of T2N, R13W, 4km (2.5 mi) downstream from the previous site, would have a capacity of 15,380 acre-feet, a firm annual yield of 22,330 acre-feet and a surface area of 277 acres.

This reservoir would inundate land within a half mile of the Anaconda-Pintlar Wilderness Area. More importantly, the dam site is currently occupied by the main buildings and lodge of the La Marche Creek Guest Ranch.

The reservoir would be about 145 km (90 mi) from the mouth of the Big Hole River. This distance would not prevent releases from the dam from reaching the lower valley since the releases would enter the Big Hole River in its canyon where there are few diversions.

The project would cost $14.58 an acre-foot of water. Because of this relatively high cost and the additional cost of the guest ranch, this site has been dropped from further consideration.

10. Old Pattengail Creek Site; SW¼, Section 10, T2N, R12W, MPM

Water released from a reservoir located on Pattengail Creek would enter the Wise River just above where it opens into a broad agricultural valley extending to the mouth of the river. Such a reservoir would yield 7,145 acre-feet annually from a reservoir of 9,040 acre-feet. The surface area would be approximately 400 acres.

Originally this was the site of a Montana Power Dam, constructed in 1901. It failed in 1927. The Bureau of Reclamation believes that the dam could be expanded to ten thousand acre-feet or more and filled and released twice a year by using an existing diversion canal which had a capacity of fifty cubic feet per second. The purpose of the previous dam was to regulate floods on the Big Hole River for power generation occurring at Divide.

The old dam would present some difficulties in construction. A large pipe would have to be removed. There is a question whether it would be better to construct another dam just in front of the old one or remove the old one and reconstruct on the same site. Taking out the old site would be an added expense, though much of it could be used for fill material on a new dam. The argillite tallus forming the south abutment, which is estimated to be 30 m (100 ft) to 45 m (150 ft) thick, would have to be removed to bedrock. This rock might be used for coarse fill. Fine material for the core of the dam may not be readily available. Part of a pack trail would have to be relocated. It is difficult to assess the impact on wildlife and vegetation in undating the four hundred acres above the dam site. The fishery and aquatic ecosystem would be changed and the free flowing status of Pattengail Creek would once again be destroyed. Critical moose winter habitat in some of the lower reaches of Pattengail Creek would be destroyed within the pool area. The moose are known to winter in the lower reaches of seveal West Pioneer Mountain tributaries to the Wise River but the relative abundance of winter habitat for the existing moose population has not been determined. The pristine value of this site has already been destroyed by the former reservoir.

At a public meeting in Wisdom held on May 25, 1978, ranchers living on this Wise River plain testified that the flows from the river are completely diverted approximately one year out of every three. This site could provide additional irrigation water and a minimum flow in Wise River. Since most of the water would re-enter the river as return flows, it would be free to enter the Big Hole River, for irrigation water and in-stream flows on the main stem. Flows leaving the dam would have to travel 95 km (59 mi) to reach Glen. Beyond this point it would be difficult to guarantee delivery of the reservoir's releases. At the size of reservoir studied, the yield would be relatively small and would have to travel 126 km (78 mi) to reach the Twin Bridges area. Hence, this project would not provide some of the in-stream flow and irrigation benefits in the locations intended by HJR 80.

The upper 2.4 km (1.5 mi) of the reservoir pool is under study for wilderness potential as directed by the Montana Wilderness Study Act of 1977. The other 1.2 km (.75 mi) of reservoir and the dam site is on multiple use national forest lands. Before a dam could be constructed, this wilderness study would have to be completed and either a negative wilderness declaration made or some sort of variance granted for lands that would otherwise be inundated within a wilderness.

Although this is a relatively small reservoir, the acre-foot cost is smallest at this size. In fact, the $3.04 per acre-foot annual amortized cost at 6 5/8 percent, is the lowest cost of any project considered and less than half the cost of any project that is being recommended for further research. Expanding the site and using the canal may increase costs.

Pattengail is a well known site in Beaverhead County and it appears to have overwhelming public support. Furthermore, because this project carries the low cost of $293,450 for development and a correspondingly low operation cost of less than $1,500 annually, this site is recommended for level C feasibility study. This study should begin as a cooperative venture with Beaverhead National Forest officials to determine how this site will be managed in the future. A site survey should also be conducted to determine the site's maximum economic size. Pattengail Creek should also be monitored for stream flow data.

11. Pintlar Creek; Section 3, T1N, R15W, MPM

A site on Pintlar Creek located a few hundred feet above Pintlar Falls would have a capacity of 7,928 acre-feet, yield 11,509 acre-feet and cover 330 acres. The site of the dam and the reservoir is about 183 km (113 mi) from the mouth of the Big Hole River and entirely within the Anaconda-Pintlar Wilderness Area.

Because of the great distance, this reservoir would probably not provide significant supplemental flows to the lower Big Hole River. The construction of the reservoir would, at times, dry up Pintlar Falls and eliminate at all times the pristine character of Pintlar Falls.

The development cost of this project would be $3.22 per acre-foot annually at 6 5/8 percent amortized over a project life of fifty years.

Further investigation of this site has been abandoned in favor of projects that could be more effectively satisfy the intent of HJR 80 without having to locate a reservoir in a wilderness area.

12. Seymour Creek; W½ Section 30, T2N, R12W, MPM

A reservoir constructed on Seymour Creek would have a capacity of 7,140 acre-feet, and cover 180 acres. The construction and operation of a reservoir at this site does not offer any outstanding benefits but also exemplifies some of the adverse effects of many sites. These facts, plus development cost of $21.06 per acre-foot, has eliminated this site from consideration.

13. Steel Creek; SE¼, Section 3, T3S, R15W, MPM

A reservoir on Steel Creek would yield 13,430 acre-feet of water with the same maximum storage capacity. The reason the firm yield and storage capacity are identical are because most of the storage would come from a diversion system from the Big Hole River. Although this site has a large yield, it is only 3 km (2 mi) from the Francis Creek site, and suffers many of that site's maladies. It is 189 km (117 mi) above the mouth of the Big Hole River, appears to lack a firm geologic base, and would cost $19.35 per acre-foot. It will not be considered further.

14, 15 and 16. Three Trail Creek Sites; SW¼, Section 18, T2S, R17W, MPM; N½, Section 21, T2S, R17W, MPM; and N½, Section 5, T2S, R18W, MPM

These three sites on Trail Creek will be considered together because of their similar characteristics and recommendations. The two sites in T2S, R17W are on the lower segment of Trail Creek and the site in T2S, R18W is above the junction of Highway 43 and the Forest Service Road 106. All of these sites are in long, narrow, flat valleys with forested low mountains bordering them. The two sites in T2S, R17W would hold large reservoirs with capacities of 19,790 and 21,720 acre-feet, yields of 28,730 and 31,530 acre-feet, and surface areas of about 500 and 460 acres, respectively. A reservoir is T2S, R18W would hold 5,020 acre-feet, yield 7,280 acre-feet and form a 180 acre lake. All three sites are between 209 km (129 mi) and 226 km (140 mi) from the mouth of the Big Hole River. This alone is enough to eliminate construction of the small reservoir on the site in T2S, R12W which also has a development cost over $21 per acre-foot. The other two sites both have excellent yields and fairly low costs. Section 18, T2S, R17W, would cost $10.72 per acre-foot and section 21, T2S, R17W, $14.36 per acre-foot. This affords some flexibility for increased costs. Neither site, however, could afford the extensive highway relocation that both would require. The reservoirs would each flood at least 6 km (4 mi) and up to 9 km (5 mi) of Highway 43. At roughly $186,000 per kilometer this road relocation would increase the project costs by a fourth to a third. The section 18 site might still be considered, but two more sites, with even lower costs, would not inundate a forest service campground as the section 18 site would. For these reasons, these three sites will not be recommended for further study.

17 and 18. Two Trail Creek Sites; Fat Man Site, SE¼, Section 14, T2S, R18W, MPM, and Thin Man Site, S½, Section 15, T2S, R18W, MPM

Since two sites on Trail Creek have similar recommendations and characteristics, they will be considered concurrently. The Fat Man site could yield as much as 15,400 acre-feet per year or as little as 10,780 acre-feet per year. The corresponding costs associated with these yields are $11.43 and $7.03 per acre-foot per year. The extreme yields for the Thin Man site are 14,100 and 10,260 acre-feet. The costs associated with these values are $10.57 and $6.59 per acre-foot per year respectively.

The geology at both sites appears to be favorable, since igneous bedrock is estimated to be between 3 and 23 m (10-75 ft) from the surface. Most of the embankment and materials would be available at the sites.

A trout fishery would be destroyed in that portion of the creek that will be inundated but could be replaced by a more productive artificial fishery. Currently, no fishable lake exists in the 83,000 acre land management unit surrounding these sites. The summer habitat that either project would destroy is only a small portion of a large range used primarily by deer and some elk. A greater impact may be a result of the highway relocation which would destroy the wildlife cover present through the right-of-way corridor. Because of the pine forest on both sides of the road, motorists would have a restricted view of big game crossing the road to reach the lake.

The Fat Man site would inundate about 3km (2 mi) of road while Thin Man site would inundate about 5 km (3 mi). Relocation of the inundated road would increase the costs about thirty-nine and thirty-eight percent respectively.

Either of these reservoirs would provide flood control by controlling forty or fifty square miles of watershed. One problem is that the sites are about 218 km (135 mi) above the mouth of the Big Hole River, however. Even though both reservoirs would have sufficiently large yields to provide supplemental flows to the lower river, there is little guarantee that water could be delivered so far downstream because of the lack of control on diversion water. These reservoirs could stabilize late sumer low flows and prevent any further dewatering in the upper valley and provide enough water to satisfy any existing irrigation demand in the upper valley from where the North Fork of the Big Hole enters the main stem to the head of the Big Hole River Canyon. The demand for irrigation in this portion of the Big Hole River basin is probably small, however.

Current recreation use in this area is high. Recreation value could be increased by the construction of either of these reservoirs.

Both sites have low development costs. The site in section 14 could be built for 2.3 million dollars, or $8.25 per acre-foot annually, and the site in section 15 for 1.5 million dollars, or $6.49 per acre-foot.

Both sites have many positive attributes, including fairly low cost and reasonably high yields. There is substantial question about how much irrigation and in-stream water could be delivered to the lower river. Therefore these sites are recommended for further investigation if it is determined that use in the upper Big Hole River basin alone would justify construction or if a way can be identified to guarantee delivery of water to the Twin Bridges area.

19. Wise River; SW¼, Section 27, T2S, R12W, MPM

A reservoir constructed on the Wise River in T2S, R12W, would have a capacity of 55,120 acre-feet, yield 43,570 acre-feet and cover 1130 acres. This site would hold the largest reservoir meeting the initial criteria. This site is 129 km (80 mi) above the mouth of the Big Hole River.

A reservoir at this site would provide flood control benefits by regulating flows from more than one hundred square miles of the most productive watershed in the Pioneer Mountains.

The geology of the site is questionable. The dam site is a glacial moraine which appears to have formed a lake and then failed. A Bureau of Reclamation report questions the water holding ability of the moraine. Large quantities of slide material on both abutments would have to be removed making the size of the fill uncertain.

Because of the size and location of this reservoir, there would be severe damage to wildlife habitat. These 1,130 acres are utilized by deer, elk and moose in the summer and are moose habitat in the winter. Since the critical moose habitat is composed of a narrow band of land in the Wise River and the lower portions of some tributaries, elimination of this much habitat would severely restrict moose winter range in the Wise River. The heavily used brook trout fishery would be destroyed and there would be only short-term brook trout fishing in the lake. Hundreds of acres of mud flats would be created from summer drawdowns.

Approximately 7.2 km (4.5 mi) of paved Forest Service highway and 1.6 km (1 mi) of improved gravel road would have to be relocated. This would add about eighty percent to the previously low development costs. Also, Lucy Ranger Station may have to be relocated.

Portions of the east bank would be in the East Pioneer Wilderness Study Area. Future management of the area will have to be determined before any construction could begin.

Because the area is wild and primitive, the area is used heavily for wilderness recreation. The construction of a reservoir at this site would destroy the pristine character and the beauty of the area.

The large yield of a reservoir on this site would provide the flexibility to allocate substantial volumes to different uses. For example, if 20,000 acre-feet were sold to provide new sprinkler irrigation over 10,857 acres of alfalfa or supplemental flood irrigation on 19,000 acres of afalfa, another 10,000 acre-feet could be allocated for in-stream flows and provide fifty-three cubic feet per second for ninety days. This would solve the severe dewatering in the lower Big Hole River, provide water to the Whitehall and Silver Star areas and still leave a 13,500-acre pool for recreation even during a dry period.

Construction, operation, maintenance and repair costs would amount to $3.08 per acre-foot. Relocation of roads and the Lucy Ranger Station would increase the cost of water from this reservoir.

Because of the uncertain geology and size of the dam, the increased costs caused by road relocation and relocation of the ranger station, the wild and primative character of the area, it is recommended that this site not be studied further.

20. Wise River; Section 20, T3S, R12W, MPM

A reservoir on the Wise River in section 20, T3S, R12W would contain 13,260 acre-feet, yield 10,480 acre-feet, and cover 359 acres. This site on the main stem of the Wise River has none of the appeal of the other Wise River site and has a development cost of $22.66 per acre-foot without road relocation considered. This site will not be considered further.

21 and 22. Two Wyman Creek Sites; Section 25, T3S, R13W, MPM, and Section 34, T3S, R13W, MPM

Two sites will be considered together. Both are small sites having yields less than seven thousand acre-feet annually and both are 142 km (89 mi) from the mouth of the Big Hole River. Neither reservoir would produce sufficient yields to satisfy the intent of HJR 80 in the lower Big Hole River basin.

The smaller upper site is in a roadless area and is part of the lands being studied under the Montana Wilderness Study Act of 1977. The site will not be considered further.

The lower site has a development cost of $9.39 per acre-foot annually at 6 5/8 percent interest, but road building that would allow heavy equipment to reach the site would add to this figure. The dam would be a long low dam and the lake shallow. In order to release flows sufficient to bring water to the lower Wise River, and possibly down to Melrose, the lake would have to be almost completely emptied every summer leaving extensive mud flats. At full capacity, about half of the reservoir pool would be in the wilderness study area. This site site will not be investigated any further.

VI. RECOMMENDATIONS

RECOMMENDED RESERVOIR SITES

Of the 120 reservoir sites originally identified, DNRC recommends seven sites for further study. These seven sites are listed in table 6 and are described in the previous chapter, "Site Identification and Evaluation." Figure 7 shows these sites' locations.

Further study of each of these sites may prove some to be more suitable than others. Specific recommendations for further study at each site as well as general recommendations for further study follow.

The **Canyon Creek site**, described on page 21, will require a survey to determine the amount of fill that would be required to construct a dam 206 feet high. This will be required before an accurate estimate of the cost of water per acre-foot can be calculated. Such a survey would cost about $3,000. If the estimated cost of the project proves it to be economically feasible, a thorough geological investigation should follow to determine whether a dam constructed at this site would be geologically sound. This investigation would require drilling six to eight core samples at an estimated cost of about $4,000 a core. In addition, the presence of a limestone kiln on the dam site and cave paintings in the immediate vicinity warrants a historic and archeological survey of the area. Such a survey would cost approximately $1,500.

The **Francis Creek site**, described on page 24, would require the drilling of three core samples to determine whether the site could safely support a dam. The cost of such an investigation would cost in the neighborhood of $4,000.

The **French Creek site** described on page 24, should be investigated by DFG to determine the impacts that a reservoir at this site would have on fish, wildlife, and recreation at this game management unit, in view of their agreement with Nature Conservancy who funded the purchase of the Mount Hagen Ranch. Futhermore, DFG should determine the possible mitigation of these adverse effects.

TABLE 6.

RESERVOIR SITES RECOMMENDED FOR FURTHER STUDY.

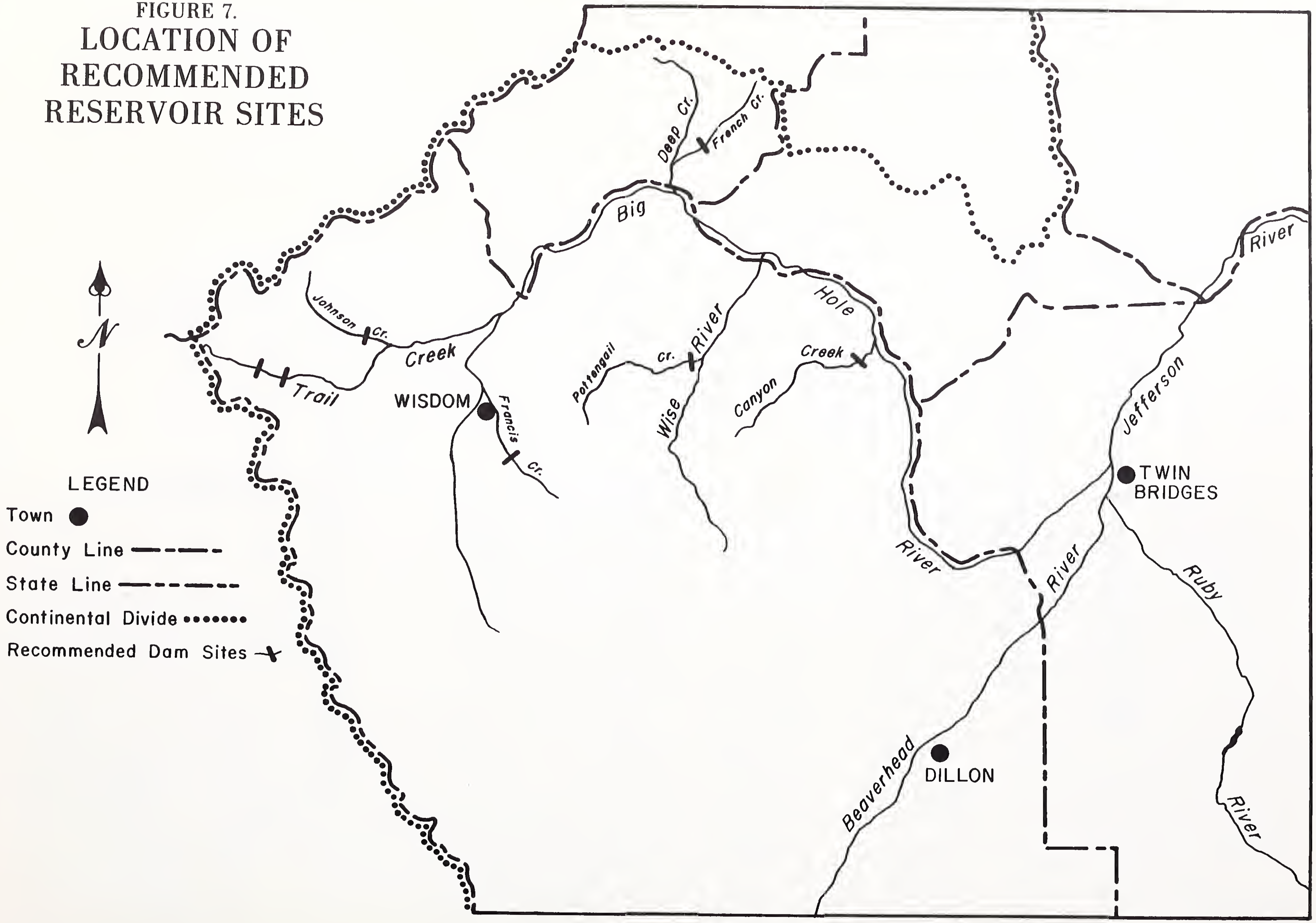
Site	Volume (acre-feet)	Yield (acre-feet/year)	Construction Costs (approximate $)	OMR* ($/year)	Cost** ($/acre-foot)
Canyon Creek, Fourth site	6,391	9,540	2.7 million	13,500	20.97
Francis Creek	9,667	9,667	1.1 million	5,594	8.68
French Creek	11,407	9,036	1.2 million	5,944	14.84
Johnson Creek	5,916	9,698	1.5 million	7,350	11.22
Old Pattengail Creek site	9,040	7,145	0.3 million	1,466	3.04
Trail Creek, Thin Man site	6,258	10,260	.9 million	4,570	6.59
Trail Creek, Fat Man site	5,390	10,780	1.0 million	5,119	7.03

* Operation, maintenance and repair.

** At 6 5/8 percent interest.

FIGURE 7.

LOCATION OF RECOMMENDED RESERVOIR SITES



The **Johnson Creek site,** described on page 25, will require a general investigation at the site that should include a cursory study of the site's geological suitability. Since the reservoir site is on private land, the owner of the land should be approached and informed of the state's interest. These investigations would cost about $700.

The **old Pattengail Creek site**, described on page 26, is partly on lands under wilderness consideration, which will require officials of the Beaverhead National Forest to determine how the land at and surrounding the site will be classified before there is any possibility of constructing a dam on this site. A cooperative effort between the U.S. Forest Service and DNRC might give DNRC an early idea of what recommendations are likely to occur. The U.S. Forest Service hopes to make its recommendation in 1981 or before. The site should be surveyed to determine the size of each potential reservoir at the site, and total cost and cost per acre-foot of each. Such a survey would cost roughly $3,000.

Water from a reservoir at either of the **Trail Creek sites**, both of which are described on page 28, would have so far to travel that it is doubtful that such a reservoir could provide the benefits desired by HJR 80. DNRC recommends, however, that demand for water in the upper Big Hole be studied to determine whether it is sufficient to justify construction of a reservoir at either of these sites. Such a study would cost approximately $10,000.

RECOMMENDATIONS FOR FURTHER STUDY

Although the amount of irrigable acres adjacent to the Big Hole, Jefferson and Missouri rivers as far down as the Canyon Ferry Reservoir has been determined, and the ability of ranchers and farmers to pay for irrigation water has been estimated, the actual interest of potential water users is still unknown. A study of the demand for water in the area should determine:

1) How many acres would actually be put under irrigation if water were available;
2) How much water users would be willing to pay for full and supplemental irrigation water;
3) Where the greatest demand for water is; and
4) How much water could be sold.

Such a study would cost about $20,000. The Montana Power Company should also be approached as a potential customer for water to use at its power generating facilities on the Missouri River.

Finally, DFG should consider applying for a reservation of water in the Big Hole River as a means of protecting the blue ribbon portion. This may be a means of preventing further degradation of this renowned fishery whether or not a reservoir can be built to provide supplemental flows.

The discussion under chapter four, "Water Rights and Related Problems," points out the need for a water monitoring system in the Big Hole River basin. If a project would be constructed, DNRC recommends that adequate means to enforce the water rights, including stream monitoring and personnel, be provided for the basin.

FUNDING

A number of federal agencies have loan or grant programs for the construction of reservoirs. Table 7 lists the best alternatives currently offered by federal agencies.

Within the state, the Renewable Resource Development program is a source of at least partial funding. These sources are, however, only available to governmental agencies. Another possible source of funds is money appropriated by the legislature.

TABLE 7.

POSSIBLE SOURCES OF FUNDING.

Agency	Program	Nature of Program
Bureau of Reclamation	Small Projects Act	Grants and loans with no interest up to $18 million for projects primarily for irrigation and secondarily for municipal and industrial water supplies, flood control, power, fish and wildlife.
Soil Conservation Service	Resource Conservation and Development	Grants and low interest loans for projects primarily for irrigation water management, flood prevention, erosion control, recreation, fish and wildlife.
Farmers Home Administration	Irrigation and Drainage Loans	Direct or guaranteed loans for projects primarily for irrigation and drainage and secondarily for soil and water conservation.
Soil Conservation Service	Watershed Protection and Flood Prevention	Grants and loans for planning, designing and construction of projects primarily for irrigation and flood control and secondarily for public recreation, fish and wildlife.

APPENDIXES

APPENDIX A.
STREAM GAGE RECORDS OF THE BIG HOLE RIVER BASIN

TABLE 8.

STREAM GAGE RECORDS OF THE BIG HOLE RIVER NEAR JACKSON, MONTANA.

LOCATION.—Lat 45° 14’ 20’’, long 113° 27’ 30’’, in NW¼ NW¼ Sec. 9 T7S., R15W., 1 mile downstream from Pioneer Creek and 9 miles southwest of Jackson.

DRAINAGE AREA.—44.0 sq. mi.

GAGE.—Water-stage recorder since June 20, 1948. Altitude of gage is 6,970 ft (by barometer). April 28, 1948, to June 19, 1848, staff gage 100 ft upstream at approximately 1.0 ft higher datum.

REMARKS.—Natural storage in lakes at headwaters. No diversion above station.

PERIOD OF RECORDS.—May 1940 - October 1954 data not continuous for winter months.

YEAR	JAN	FEB	MAR	AP	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
MAX.	—	—	—	3,890	13,190	19,230	8,160	2,550	1,280	1,580	1,260	—	—
MIN.	—	—	—	2,470	4,660	8,470	2,460	974	770	635	508	—	—
AVE.	583*	547*	602*	3,180	9,820	13,438	5,540	1,714	993	993	833	756*	37,753*

*3 years of data only.

TABLE 9.

STREAM GAGE RECORDS OF THE BIG HOLE RIVER NEAR MELROSE, MONTANA.

LOCATION.—Lat 45^0 31' 36'', long 112^0 42' 03'' in SE¼ SE¼ SW¼ Sec 34, T3S., R9W., Madison County, on left bank at downstream side of bridge on Interstate Highway 15 and U.S. Highway 91, 0.1 mi (0.2 km) downstream from Rock Creek, and 7 mi (11.3 km) south of Melrose.

DRAINAGE AREA.—2,476 mi^2 (6,413 km^2)

PERIOD OF RECORD.—October 1923 to current year.

GAGE.—Water-storage recorder. Datum of gage is 5,032.87 (1,534.018 m) above mean sea level. Prior to June 14, 1927, water-storage recorder, and July 17, 1927, to September 30, 1931, nonrecording gage, at site 1.7 mi (2.7 km) upstream at different datum.

AVERAGE DISCHARGE.—51 years, 1,141 ft^3/s (32.3 m^3/s), 826,700 acre-ft/yr (1.02 km^3/yr).

REMARKS.—Records good except those for winter period and periods of no gage-height record, which are poor. Diversions for irrigation of about 136,000 acres (550 km^2) above station.

YEAR	JAN	FEB	MAR	AP	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
MAX.	32,610	44,430	56,890	209,200	510,000	498,700	208,400	89,590	51,770	68,160	61,720	46,920	1,364,470
MIN.	8,780	7,950	15,220	29,150	73,010	60,890	15,590	7,820	8,130	11,280	15,170	13,690	322,720
AVE.	45,645	51,387	28,004	93,054	287,554	244,070	85,171	30,431	26,735	30,105	29,973	24,186	818,641

*3 years of data only.

APPENDIX B.

A PROCEDURE FOR PRELIMINARY SIZING OF RESERVOIRS IN SMALL UNGAGED MOUNTAIN WATERSHEDS

DETERMINING AVERAGE ANNUAL FLOW IN UNGAGED MOUNTAIN WATERSHEDS

Various methods, equations and publications have been offered to calculate annual flows and flow variations on ungaged watersheds. DNRC adopted a procedure based on the fundamental relationship between precipitation and runoff (USDA 1971). The study was aided by the Soil Conservation Service's (SCS) state-wide precipitation map based on U.S. National Weather Service data, and SCS snow survey water equivalence data (UDSA 1977). Plotting a graph of precipitation against runoff yielded a curve that represented the relationship between the two. The curve was verified on several western U.S. watersheds and the results indicated that as precipitation increases, the proportion of that precipitation that becomes runoff also increases (USDA 1971). After verifying the curve, curves were developed for specific watersheds that could convert inches of precipitation directly to inches of runoff. From this, the volume of runoff produced from a certain amount of precipitation falling on each of the subbasins of the Big Hole River basin was calculated (USDA 1975). With this information all small subbasins above a reservoir site were evaluated by planimetering isohyets to determine precipitation over each watershed, and converting that average to an average volume of runoff.

RESERVOIR SIZING

Where adequate stream gaging records were available, mass diagram analysis was used to size reservoirs (Linsley 1972). The mass diagram was plotted for the lowest three-year period on record for Birch Creek and Wise River. These flows were adjusted to allow for base flow and senior water rights. Through the mass diagram analysis a relationship was developed between reservoir yield and capacity for each of the two streams; a maximum storable volume was also calculated. The relationship was then applied to adjacent or similar ungaged streams where reservoir sites had been identified. With the calculated average annual flows for those streams, maximum reservoir capacities were generated at each site.

Because gaging records for Trail Creek do not include a critically dry period, low flows were generated for Trail Creek through correlation and regression analysis with the East Fork of the Bitterroot River. Consequently, this data is not as reliable as the U.S. Geological Survey data used in the Birch Creek and Wise River analyses. A mass diagram analysis was then performed using the generated flows for Trail Creek and the derived storage-yield relationship applied to streams similar to Trail Creek. Table 10 indicates which storage-yield relationship was applied to each of the seven recommended sites.

TABLE 10.

STORAGE-YIELD RELATIONSHIPS USED TO DETERMINE POTENTIAL RESERVOIR SIZES.

Storage-Yield Relationship	Reservoir Sites
Birch Creek	Canyon Creek
Wise River	Pattengail Creek
Trail Creek	Deep Creek Francis Creek French Creek Johnson Creek Trail Creek, Fat Man Site Trail Creek, Thin Man Site

APPENDIX C.
THE VALUE OF IRRIGATION WATER

The value of irrigation water was calculated by comparing the profitability of existing range land operations and the profitability of a new irrigation system. Farm budgets for range land and irrigated alfalfa were calculated for bench lands near the Big Hole River in the area between Melrose and Whitehall. The new irrigation is assumed to be located on land one-quarter of a mile from the Big Hole River and at an elevation one hundred feet above the river. The economic analysis centers on the comparison of the expected profits per acre on the potentially irrigable land and the expected profits per acre on the existing range land that would be converted to irrigation. The difference between the profits per acre on irrigated alfalfa and range land is the economic incentive to convert range land to irrigated alfalfa. The irrigated alfalfa budgets do not include the costs of purchasing stored water. This means that a new irrigation project will only increase farm profits if the water purchase costs per acre are less than the increase in profits per acre due to irrigation. Put in another way, the value of irrigation water per acre-foot is equal to the increase in profits per acre due to irrigation, divided by the number of acre-feet required to irrigate a typical acre. A farmer that can purchase stored water for less than the increase in profits it produces will find it profitable to convert to irrigation. The following analysis will first present the costs and revenues for irrigated alfalfa and second the costs and revenue for range land.

Costs and revenue estimates for irrigated alfalfa were made for flood irrigation and a wheel-line sprinkler system. These estimates assumed (1) alfalfa hay would be grown on an eight-year rotation schedule; (2) yields would be 3 tons per acre for flood irrigation and 3.5 tons per acre for sprinkler irrigation; (3) water diversions would be 2.25 acre-feet per acre for flood systems and 1.75 acre-feet per acre for a sprinkler system; and (4) hay would be sold as a cash crop for $50 per ton. Table 11 presents the budgets used to estimate costs and revenues for irrigated alfalfa.

The economic analysis of range land revenues and costs is based on a farm budget on a 1700 acre ranch in Madison County that runs a cow-calf operation. This typical ranch has 1500 acres of range land which are valued at $100 per acre and 200 acres of alfalfa which are valued at $500 per acre. Table 12 presents the annual revenues from the sale of cattle.

The total value of the ranch land is $250,000 (1500 acres x $100 + 200 acres x $500). The portion of the revenue attributable to range land operation is approximately equal to the proportional value of the range land on the ranch. The range land is worth $150,000 and the entire ranch is $250,000 so it is reasonable to assume that the range land produces about 60 percent of ranch revenue. This 60 percent of the estimated $43,000 annual revenue is $25,800 and the revenue per acre of range land is about $17.20. Table 13 presents the costs and revenues of this typical range land operation.

TABLE 11.

COSTS AND REVENUE PER ACRE FOR IRRIGATED ALFALFA.

COSTS		
Variable Costs	**Flood**	**Wheel Line**
Fertilizer	$ 16.75	$ 16.75
Irrigation labor	7.27	7.27
Stand establishment	1.55	1.55
Tearing out alfalfa	5.19	5.19
Machinery (fuel, oil and repairs)	10.21	10.21
Pickup	2.70	2.70
Miscellaneous expense	7.06	7.06
Interest on operating capital (9¼%)	1.01	1.01
Machinery labor	7.53	7.53
Sprinkler system (wheel line) (electric and maintenance)	7.00	16.70
Total variable costs	**$ 66.27**	**$ 75.97**
Fixed Costs		
Pump and pipe facilities	13.99	
Pump and pipe facilities and sprinkler system		30.76
Taxes and insurance on land and improvement	7.19	7.19
Buildings	2.43	2.43
Machinery ownership	20.63	20.63
Interest on land (7%)	28.00	28.00
Total fixed costs	**72.24**	**89.01**
Total Costs	**$138.51**	**$164.98**
REVENUE		
Revenue per acre (3 tons x $50)	150.00	
(3.5 tons x $50)		$175.00
Less: fixed and variable costs/acre	-138.51	-164.98
Net Income/Acre	**$ 11.49**	**$ 10.02**

SOURCE: Cooperative Extension Service April 1978 and March 1978.

TABLE 12.

ANNUAL REVENUES ON A 1700 ACRE MADISON COUNTY RANCH.

Animals	**Weight (lbs)**	**Price/lb. ¢**	**Revenue ($)**
81 steer calves	450	60¢	$21,870
54 heifer calves	425	55¢	12,623
25 cull cows and heifers	950	27¢	6,413
3 bulls	1800	37.5¢	2,025
			$42,931

SOURCE: Cooperative Extension Service 1977.

TABLE 13.

REVENUE AND COSTS PER ACRE FOR A 1700 ACRE MADISON COUNTY RANCH.

Revenue		**$17.20**
Less Costs:		
Variable Costs		
Feed	$ .73	
Seed, fertilizer, twine	.25	
Veterinarian and medicine	.29	
Labor	1.00	
Fuel and oil	1.26	
Repairs	1.68	
Utilities	.08	
Miscellaneous	.36	
Interest on operating capital	.35	
Total Variable Costs	**$6.00**	
Fixed Costs		
Taxes and insurance	$1.72	
Machinery and land	5.33	
Total Fixed Costs	**$7.05**	
Total Costs		**$13.05**
Net Income		**$ 4.15**

SOURCE: Cooperative Extension Service 1977.

Table 14 derives the difference in net increase per acre between irrigated alfalfa and range land.

Table 14 indicates that a conversion of range land to irrigated alfalfa will increase net income by $3 to $4 per acre. If water were made available at a price less than about $3.25 per acre-foot, the conversion of range land to irrigated alfalfa would increase net income on the operation because the value of the water in the conversion is about 3.25 per acre-foot. Because this is only a cursory analysis of these costs and revenue estimates, the results contain a considerable margin for error. More detailed studies on specific land would be required to estimate more precisely the value of irrigation water in the basin.

TABLE 14.

VALUE OF IRRIGATION WATER IN THE BIG HOLE RIVER BASIN.

	Flood	Wheel line
Net income/Acre on alfalfa	$11.49	$10.02
Less: Net income/Acre on range	4.15	4.15
Net income/Acre on conversion	$ 7.34	$ 5.87
Irrigation diversion requirements Acre-feet/Acre	÷ 2.25	÷ 1.75
Value/Acre-foot	$ 3.26	3.35

APPENDIX D.
HOUSE JOINT RESOLUTION 80

A JOINT RESOLUTION OF THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA REQUESTING THE DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION TO STUDY THE FEASIBILITY OF OFF-STREAM STORAGE ON THE UPPER BIG HOLE RIVER.

WHEREAS, the need for watershed and irrigation development is critical for the continued growth of agriculture in Montana and has been revealed by severe summer droughts; and

WHEREAS, the climatic and soil conditions of Broadwater, Jefferson, and Madison Counties are such that irrigated land produces a high proportion of the total value of the crops; and

WHEREAS, the economy of Montana is enhanced by a more stable farm income, and a stable farm income is in part related to a reliable water supply; and

WHEREAS, the Big Hole and Jefferson Rivers are considered by many people to be among the finest fishing streams in Montana, and in many years very low flows during late summer months and high turbid flows during spring months have limited fishing on both streams; and

WHEREAS, the need exists for increased control of river flows during periods of heavy spring runoff which flood the Jefferson River and its tributaries and have frequently caused damage to farmland, irrigation, communication and transportation facilities, and other improvements along the streams; and

WHEREAS, the potential for control of the destructive spring flows and for enhancing late summer flows exists in off-stream storage of the upper Big Hole; and

WHEREAS, it is becoming apparent that if Montanans do not plan to use Montana water for their own benefit, they will lose the water rights to the demands of downstream users in other states where water is appropriated to a beneficial use, prior in time.
NOW, THEREFORE, BE IT RESOLVED BY THE SENATE AND THE HOUSE OF REPRESENTATIVES OF THE STATE OF MONTANA:

That the Senate and the House of Representatives of the State of Montana request the Department of Natural Resources and Conservation to study the feasibility of off-stream storage on the upper Big Hole River and report to the 46th Legislature on the results of that study including therein:

(1) a description of each unit considered;

(2) the benefits and costs associated with each unit; and

(3) a recommendation as to the best practical unit to construct and the potential sources of funding for the construction of that unit.

BE IT FURTHER RESOLVED, that this project be funded through the water works project feasibility study program.

Approved March 22, 1977.

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ABBREVIATIONS

BLM	Bureau of Land Management, U.S. Department of the Interior
cfs	cubic feet per second
cm	centimeters
DFG	Montana Department of Fish and Game
DHES	Montana Department of Health and Environmental Sciences
DNRC	Montana Department of Natural Resources and Conservation
ft	feet
gpm	gallons per minute
HJR 80	House Joint Resolution No. 80
HJR 1	House Joint Resolution No. 1
km	kilometers
m	meters
m^3/s	cubic meters per second
mi	miles
OSS	Office of the Secretary of State, Montana
R.C.M. 1947	Revised Codes of Montana, 1947
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey, U.S. Department of the Interior
USDI	U.S. Department of the Interior

BIG HOLE RIVER

MONTANA
DEPARTMENT OF NATURAL RESOURCES
& CONSERVATION

Helena, Montana